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#208 SEPTEMBER 2022

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

DRAMATIC FIRST IMAGES

WONDERFUL WEBB

What JWST's stunning first photos really show **PLUS** its science journey explained

PULL-OUT SKY GUIDE

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SPECTACULAR PLANETS: SEE 5 WORLDS IN ONE NIGHT

HOW TO ANIMATE JUPITER AT ITS BRIGHTEST & BEST

HANDS FREE: A BINOCULAR MOUNT FOR YOUR SUNBED

THE FIRST BLACK WOMAN IN SPACE, 30 YEARS ON

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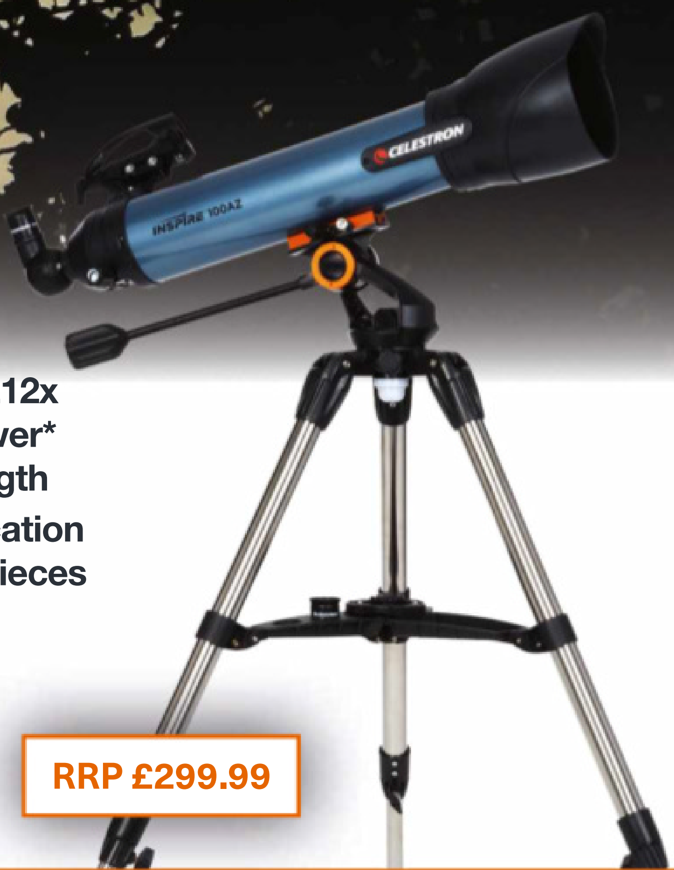

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Welcome

Webb is here – and it's a case of love at first sight

On 12 July the *Sky at Night Magazine* team waited with bated breath, excited to see the first images from the James Webb Space Telescope. And they did not disappoint. We were spellbound and amazed by the detail, depth and structure JWST captured. See for yourself on **page 6** in our special Eye on the Sky gallery, which we've dedicated entirely to the infrared telescope's first images.

And then came the science. We sat wide-eyed as Webb's ability to break down light into its component parts through spectroscopy was revealed, dazzled that we were being shown individual elements in dust clouds circling the event horizon of a supermassive black hole 310 million lightyears away. Yet this is just one part of JWST's science programme; turn to Colin Stuart's feature on **page 28** to discover the other areas the telescope will impact. Also in this special issue, on **page 18** we hear from astrophysicist Mikako Matsuura about working with JWST, and *The Sky at Night* presenter Chris Lintott gives his thoughts on Webb's first images on **page 11**.

Back on Earth, it's an exciting time to be observing the night sky. Jupiter is at opposition and at its brightest, a great time to follow Pete Lawrence's guide to making an animation of it on **page 66**. The King of Planets is joined by four of the Solar System's other worlds all this month, creating an enchanting line-up in evening skies. Turn to **page 35** for Stuart Atkinson's advice on seeing this planetary parade.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Friday 16 September.

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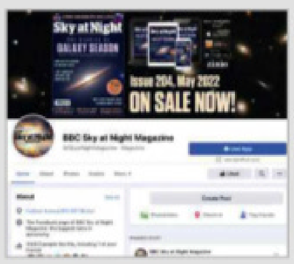
Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

Online
Visit our website for competitions, astrophoto galleries, observing guides and more



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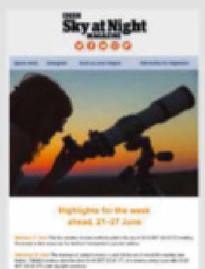

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Find out more at: www.skyatnightmagazine.com

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C = on the cover ⬡ = JWST special

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The Sky Guide C

16-PAGE CENTRE PULLOUT

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Paul Money

Reviews editor

"Globular clusters always remained fuzzy blobs until I added more aperture to view them, revealing their distinct and individual personalities in all their glory." **Paul introduces 15 globulars you really should meet, page 60**

Melissa Brobby

Amateur astronomer

"It was fascinating to talk to Rajeev about the changing views on space today, compared to how it was during the Apollo era." **Melissa finds out what the younger generation think about space, page 98**

Ezzy Pearson

Features editor

"Mae Jemison really has some drive. From a little girl in Detroit watching *Star Trek* to the first Black woman in space, to leading humanity's way across the stars." **Ezzy salutes multi-talented Mae on page 72**

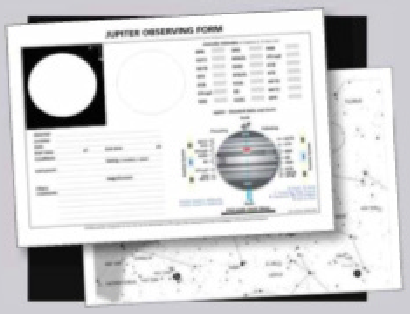
Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/VOCFQDB** to access this month's selection of exclusive Bonus Content

SEPTEMBER HIGHLIGHTS

Interview: the science behind JWST

Instrument scientist Dr Pamela Klaassen reveals how the James Webb Space Telescope observes the Universe.



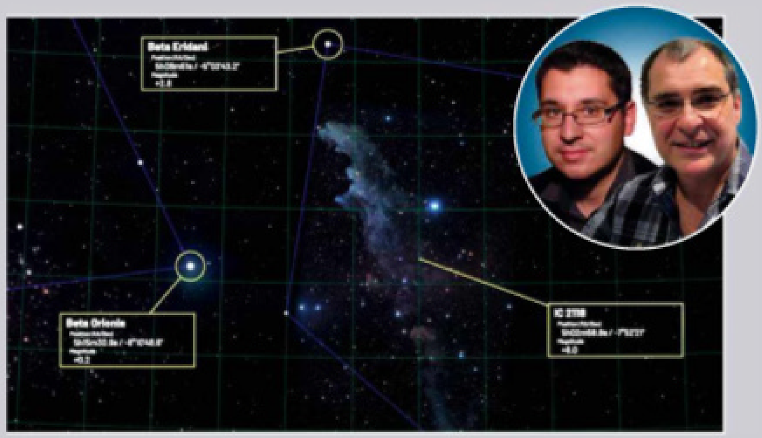
Watch online: *The Sky at Day*

Summer sees the nights get shorter. In this special episode, Maggie and Chris reveal what to see in the sky during the day.

Download astronomy observing forms

Print out our report forms to help you keep track of all your planetary and solar observing sessions.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

NASA/ESA/CSA/STSCI

JWST LIGHTS UP THE UNIVERSE

In July, a momentous new era in space science began when NASA released the first full-colour images from the James Webb Space Telescope. We look at the first five that stunned the world

Captured in infrared light, this image of 'Cosmic Cliffs' within the Carina Nebula, 7,600 lightyears away, reveals structures and star-forming regions previously unseen by human eyes. It's a much-loved target for amateur astronomers and astrophotographers, but no one will ever have seen it like this.

This glowing 'wall' is the edge of a cavity within the nebula that features peaks of cosmic gas and dust seven lightyears high. It's being hollowed out by the intense radiation emitted by newborn stars located just above the area shown in the image. The 'haze' that seems to be rising from the wall is ionised gas and hot dust streaming away from the nebula under relentless radiation pressure.

Webb's NIRCam instrument, which was used to capture this image, observes in infrared, enabling astronomers to peek through the dense cosmic dust and get a good look at what's really going on at the heart of this nebula. What we are seeing are views of these stellar nurseries and pockets of young stars that until now were beyond humanity's reach.

Commenting on Webb's first images, NASA deputy administrator Pam Melroy said: "What I have seen moved me, as a scientist, as an engineer and as a human being." Having seen them now for ourselves, it's difficult not to agree with her.

TURN THE PAGE FOR MORE OF WEBB'S BRAND NEW IMAGES

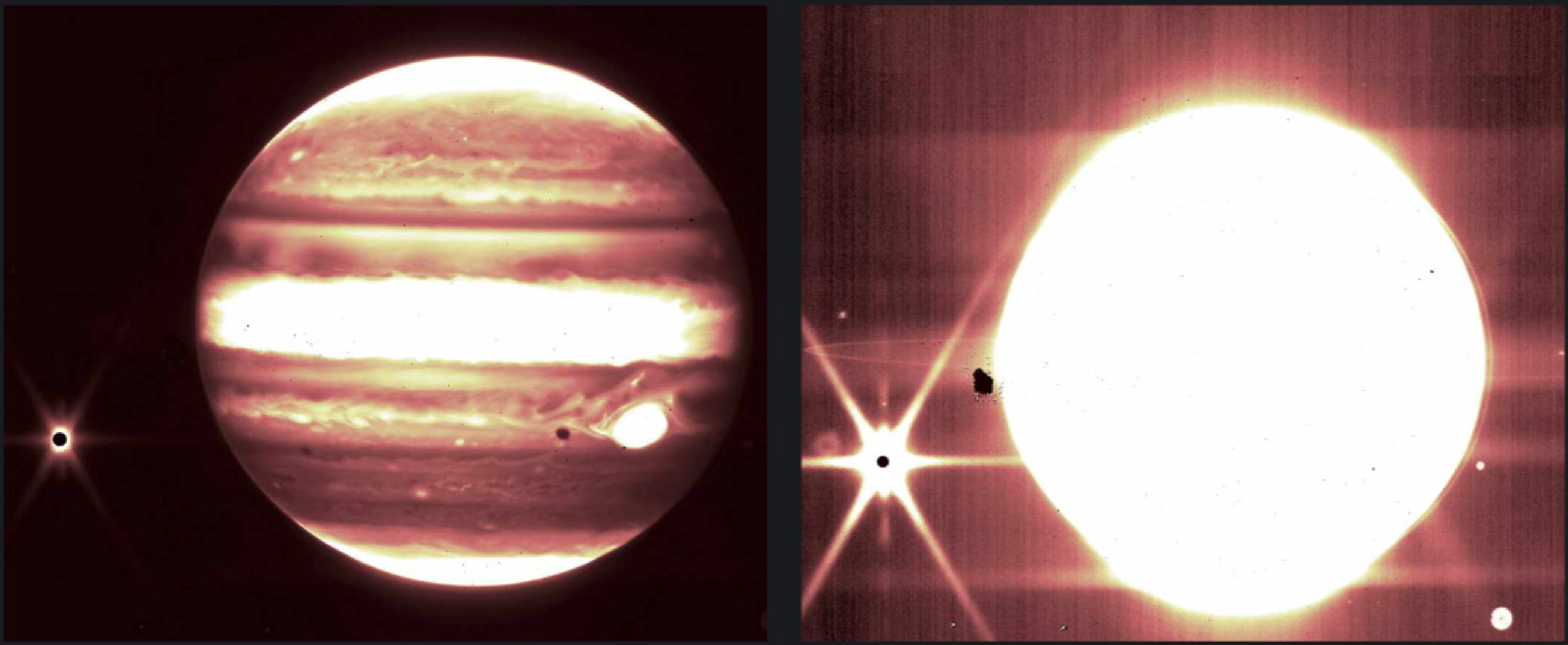
△ Field of dreams

This is the deepest infrared image of the distant Universe ever captured. Webb's First Deep Field is bursting with thousands of galaxies, but the focus is SMACS 0723, a galaxy cluster so far away it appears to us as it did 4.6 billion years ago. Its mass is so staggering that the light from background galaxies is magnified and contorted by gravitational lensing. This image alone is a treasure trove for scientists to unpack.

◁ Two glorious rings

Not one view of the Southern Ring Nebula, but two. This is a planetary nebula, a dying star shedding its layers into space, captured in both near-infrared (left), and mid-infrared (right) where we can actually see the remnant white dwarf core (the redder of the two).

NASA/ESA/CSA/STSCI X 6



△ Target practice

Captured during the testing phase that would refine Webb's incredible imaging powers, this image of Jupiter honed the telescope's instruments before science operations officially began on July 12. In it we can see the planet's distinctive rings, as well as its moons Europa, Thebe and Metis. We can also see a region of dead pixels on one of the camera's detectors, the black spot on the second image.

◁ Five for the price of one

Webb's largest image yet, Stephan's Quintet – a group of merging galaxies – covers an area one-fifth the size of the Moon. The telescope's near- and mid-infrared instruments combined to reveal never-before-seen features within the galaxies, as well as shockwaves caused by galaxy NGC 7318B smashing through the cluster.

MORE ONLINE

Explore a gallery of these and more stunning space images

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

JWST unveils its first images

The incredible pictures took just one week of observing time to create

After decades of waiting, the James Webb Space Telescope (JWST) has released its first scientific images to the public.

"Today, we present humanity with a ground-breaking new view of the cosmos – a view the world has never seen before," said NASA administrator Bill Nelson.

On 11 July, President Joe Biden was given an advance view of the images, and thanked "the team at NASA for once again showing who we are".

The first deep-field image was released that evening. The next day, on 12 July, NASA released three more images, as well as a spectra of exoplanet WASP-96b's atmosphere, which showed clear signs of water. Before long, the images were shared on news channels and social media the world over, as people marvelled at the unprecedented detail in the images – all of which were taken within a single week of observing time.

"The Hubble Deep Field was two weeks of continuous work with Hubble. We did [ours] before breakfast," says Jane Rigby, operational project scientist for JWST. "The amazing thing about Webb is the speed with which we can churn out discoveries."

But while the images stunned the world, a report on JWST's performance revealed an unexpectedly large micrometorite strike in May has caused a "significant uncorrectable change" to one of the mirror segments. Fortunately it only affects a small area and JWST is still performing above expectations.

To see the first images turn to **page 6**, and learn more about the science that JWST is set to deliver on **page 28**.
webbtelescope.org

▲ **President Biden reveals the first full-colour image – the deepest infrared picture of the Universe yet – to a waiting world**

Comment

by Chris Lintott

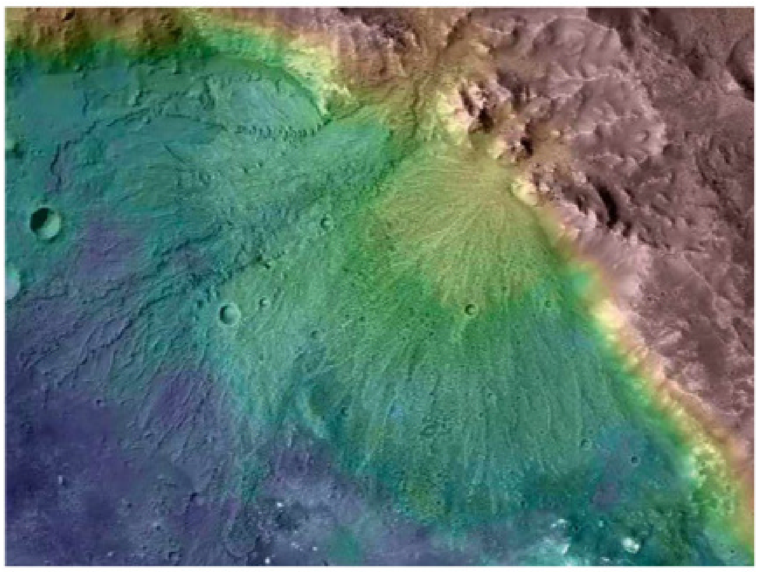
I was wrong. Utterly, wonderfully wrong. For over a decade, I've flinched when space agency press releases described JWST as the successor to the Hubble Space Telescope. Though both are incredible tools for science, Hubble is best known for its spectacular images. JWST, though, is an infrared telescope; working with wavelengths beyond what our eyes can see inevitably makes the view blurrier. Setting up JWST as a machine capable of producing images as beautiful as Hubble's, no matter their scientific utility, was asking for disappointment.

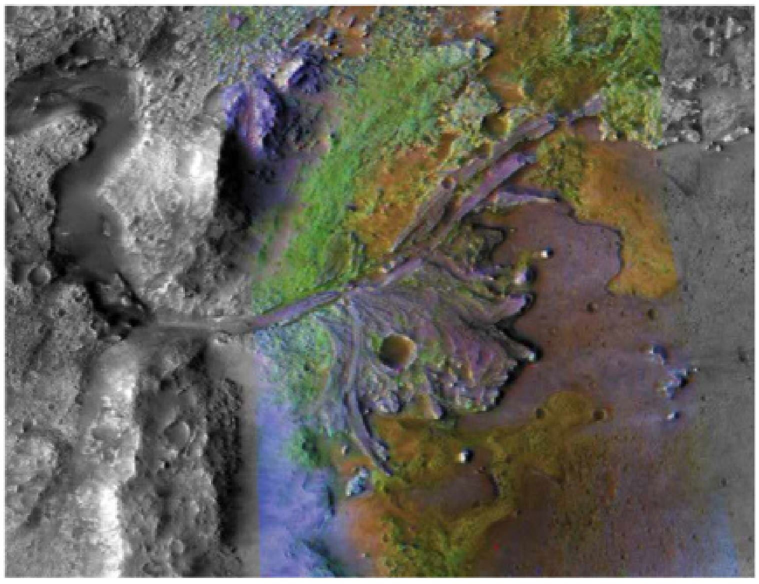
Wrong, as I said. I have the JWST image of the Carina Nebula as my laptop background, and Stephan's Quintet on my phone. It turns out that a mirror six metres across is large – large enough to produce crystal-clear, pin-prick-sharp images to wow the world.

Welcome to the infrared Universe! Beautiful, isn't it?

Chris Lintott co-presents *The Sky at Night*

NASA/BILL INGALLS





◂ An alluvial fan in Tian Shan, China. Similar fans (top) and river deltas (above) have been imaged on Mars

Fans help reveal Mars's watery past

Water may have flowed across Mars for millions more years than previously thought

A new study shows water could have been flowing across the surface of Mars as recently as 2.5 billion years ago. Although Mars is now an arid planet, its surface is covered with geological evidence that it was once host to liquid water. What's not so clear, however, is when this water disappeared.

"We've known for decades that Mars had rivers and lakes around 3.5 billion years ago, but in the past few years there has been a growing body of evidence that substantial amounts of liquid water continued to erode the Martian surface for hundreds of millions of years," says Alexander Morgan from the Planetary Science Institute.

To further investigate, Morgan has led a new study surveying fan-shaped features seen across Mars. These are a mixture of the remains of river deltas and alluvial fans, which are created by sediment building up at the mouth of a narrow channel. Both require vast amounts of flowing liquid water to form, so are a clear indicator of its presence. By analysing these, Morgan's team found that as Mars cooled and dried, liquid water was increasingly restricted to the lower, warmer regions of Mars.

In a second paper, the team compared the alluvial fans to previous work on the planet's valley networks, which have already been studied as indicators of past water. While the valleys were largely formed around 3.6 billion years ago, the alluvial fans formed more recently, 2.5 to 3 billion years ago, giving the researchers an insight into how the environment had changed between those dates.

"We found that even though Mars cooled over time, from global average temperatures of –3°C to about –15°C, liquid water continued to be stable in select areas," says Morgan. "Together, these papers describe how Mars had liquid water in the form of rivers for a prolonged period, from about 3.6 to at least about 2.5 billion years ago."

However, what the studies don't show was whether the planet's climate stayed consistent during that time.

"We don't believe Mars was wet for this entire period," says Morgan. "Conditions that permitted liquid water may have been episodic, perhaps driven by changes in Mars's movements – such as axial tilt, orbital eccentricity or precession – or volcanic activity."

www.psi.edu

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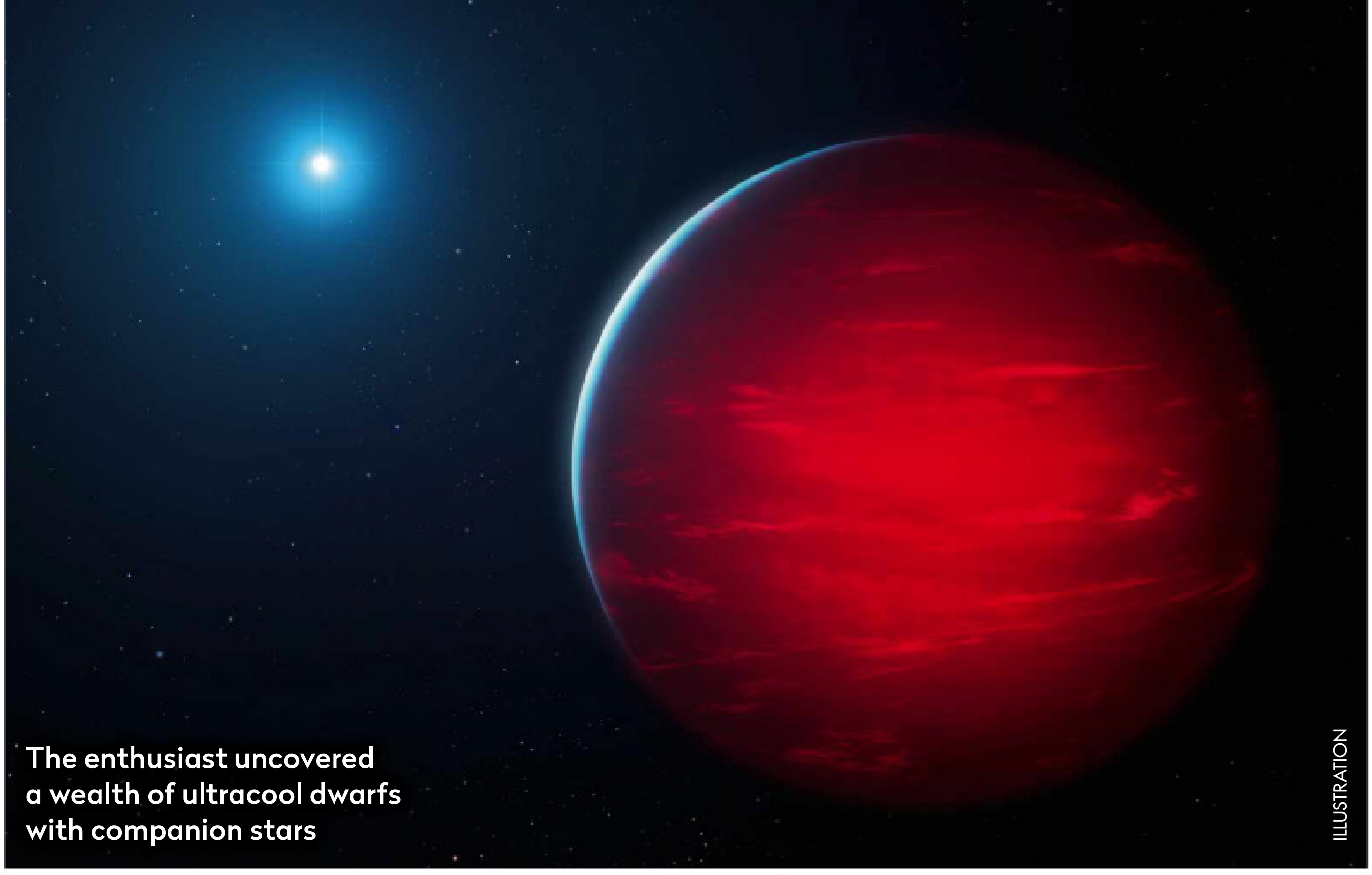


The enthusiast uncovered a wealth of ultracool dwarfs with companion stars

Binary dwarfs found by amateur astronomer

The discovery continues a long tradition of citizen science

Citizen scientist Frank Kiwy has helped find 34 ultracool dwarf binary systems – doubling the number previously known.

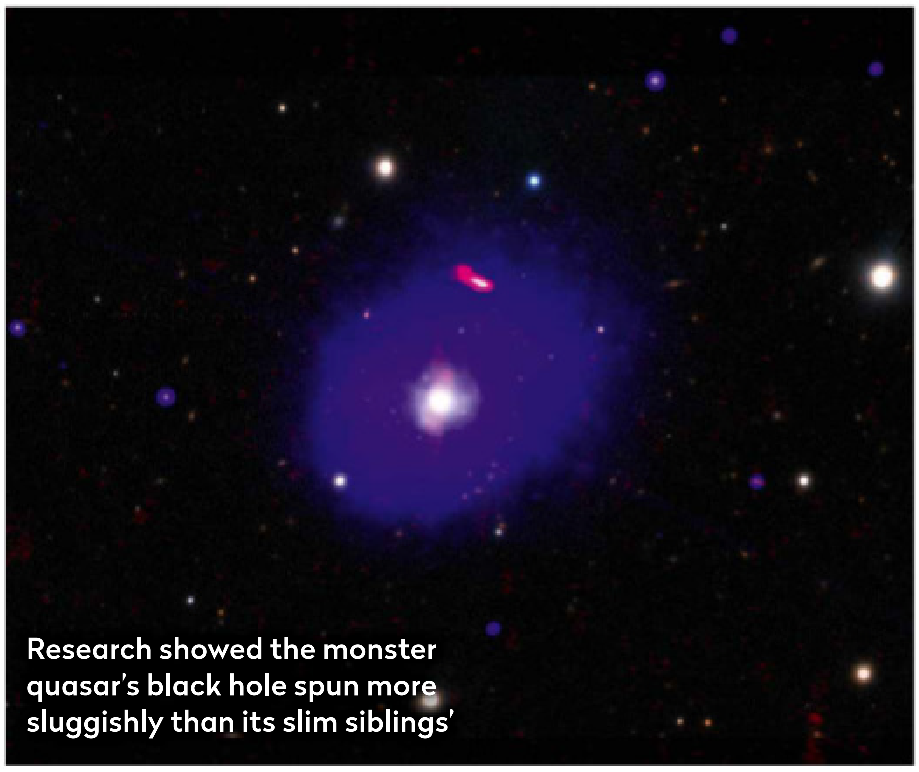
Brown dwarfs are too small to be stars but too large to be planets. Their faintness makes them difficult to find, so the Backyard Worlds: Planet 9 project asked over 100,000 members of the public to search images for signs of them moving against background stars. Enthused by the project, member Kiwy embarked on his own quest, searching through the data to find objects based on their colour. This led to the identification of 2,500 ultracool dwarfs, 34 of which were later found to have low-mass companion stars.

"I love the Backyard Worlds: Planet 9 project!" says Kiwy. "Once you master the regular workflow you can dive much deeper into the subject. If you're a person who is curious and not afraid to learn something new, this might be the right thing for you."
www.zooniverse.org

Giant black hole is slower than its peers

The largest black hole to ever have its spin measured is turning slower than its smaller siblings, a new study reveals.

"Every black hole can be defined by just two numbers: its spin and its mass," says Julia Sisk-Reynes from the University of Cambridge, who led the new research. "While that sounds fairly simple, figuring those values out for most black holes has proved incredibly difficult."

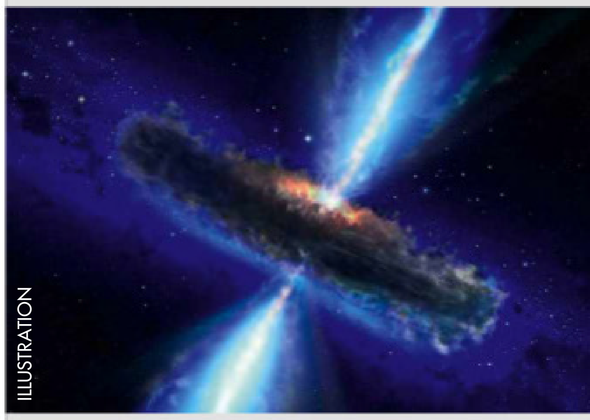


Research showed the monster quasar's black hole spun more sluggishly than its slim siblings'

The black hole at the heart of quasar H1821+643 in the constellation Draco is a colossal 30 billion solar masses, around 10,000 times more massive than the Milky Way's central black hole. Astronomers measured its spin by looking at X-rays bouncing off the material surrounding it, and found its rotation to be about half the speed of black holes between one and 10 solar masses. It's thought that these monsters grow by merging together, which disrupts their rotation, slowing them down. The more they grow, the more they slow.

"The moderate spin for this ultra-massive object may be a testament to the violent, chaotic history of the Universe's biggest black holes," says co-author James Matthews.
www.ast.cam.ac.uk

NEWS IN BRIEF



Extreme neutrinos

Extragalactic neutrinos – highly energetic, difficult to detect particles – probably come from active galactic nuclei, where a galaxy's central black hole superheats the surrounding gas. These extreme conditions create jets travelling at nearly the speed of light, which shoot out the particles with enough energy to cross the billions of lightyears between galaxies.

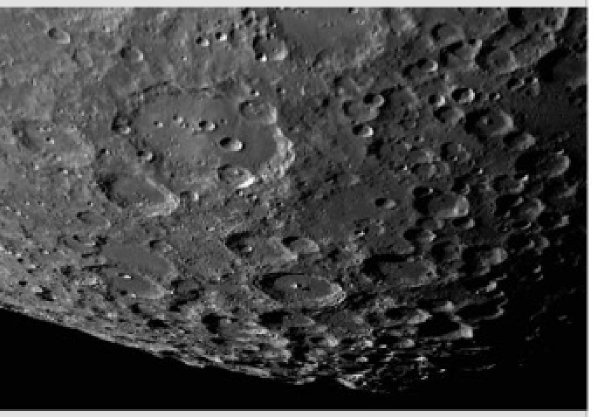
Radio radiation located

Astronomers have been using radio and infrared radiation to measure star formation in galaxies for 50 years, but have only now worked out where this radiation comes from. Young massive stars heat up the surrounding gas, causing it to glow in the infrared, then explode in supernovae that create radio waves.

NLCs on the rise

This July was a bumper month for noctilucent clouds, with sightings extending far further south than normal, while NASA's AIM spacecraft measured the strongest NLC activity in over 15 years. The number of clouds has been rising in recent years, with greenhouse gases and water vapour from rocket launches being potential causes.

NEWS IN BRIEF



Small impacts bombarded Moon

The early Moon may have sustained twice as many impacts as previously thought. Measurements taken by NASA's Gravity Recovery and Interior Laboratory spacecraft have shown that between 4.3 to 3.8 billion years ago, small meteors compacted the lunar surface. This suggests the number of craters seen today could represent only half the number of strikes.

Russia to withdraw from the ISS in 2024

Roscosmos, the Russian space agency, has officially announced that it will leave the ISS in 2024 once its existing agreement runs out. Newly appointed agency chief Yuri Borisov stated Russia will now focus on building its own station.

UK space launch due

Virgin Orbit will launch its next satellite from the UK later this year. The satellite will be carried into orbit on board a modified Boeing 747 from Spaceport Cornwall. This is one of several planned UK launches as part of the government's aim to become the first European country to launch a satellite from home soil in 2022.

STEVE MARSH, NASA, INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/NSF/AURA

BULLETIN

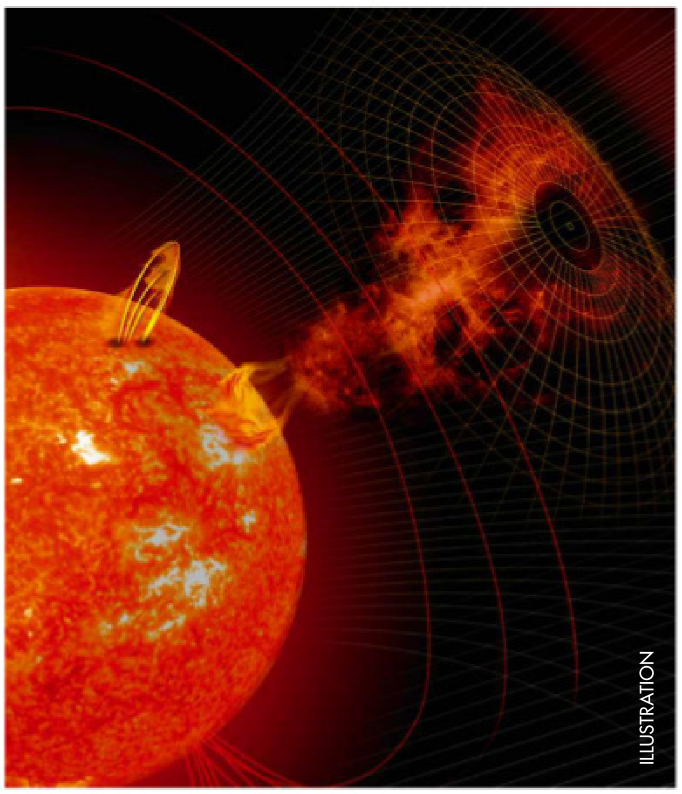
Solar storms cause train delays

Sun's activity found to mimic the system used for train signalling

'Your train has been delayed due to a signalling failure' is a phrase commuters will be all too familiar with. While most of us might lay the blame on snow or rain, a recent report suggests another type of weather could also be at fault – space weather.

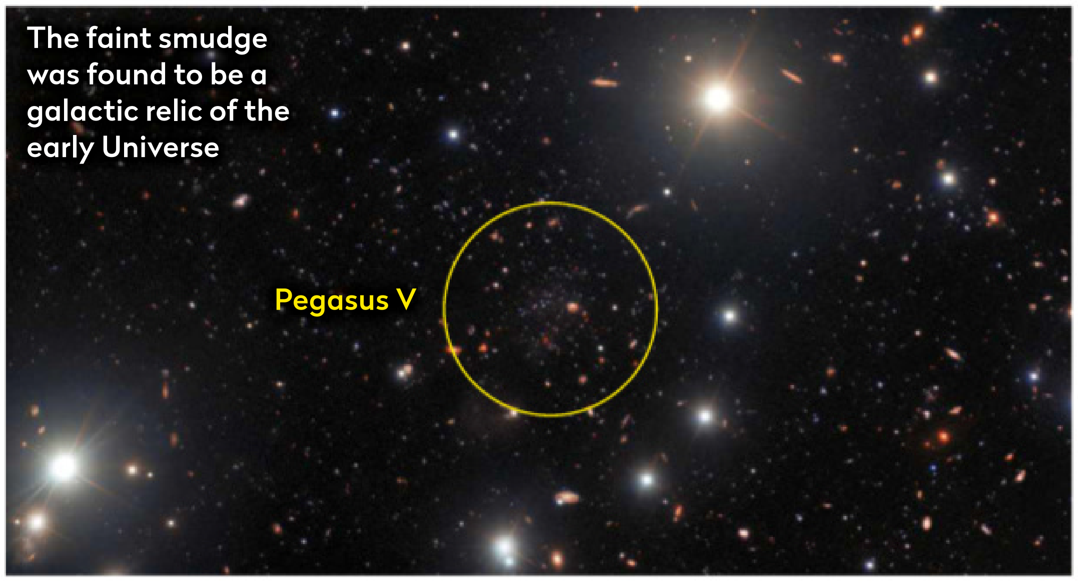
Train signalling systems use electric currents in the rails to determine if a train is present on a given section of track, showing a red light if it detects one. However, solar storms also cause similar currents to form in the rails and it only takes a moderate event to trigger a red signal, even when there's no train present.

"We are now working on looking at the case where trains are present on the line, and how strong a solar storm needs to be to turn a red signal back to green," says Cameron Patterson from Lancaster University, who investigated the phenomenon. "That's a far more hazardous scenario, potentially leading to crashes!"
www.lancaster.ac.uk



▲ **Solar flares and coronal mass ejections – the possible culprits for train signalling glitches**

Fossil galaxy lies near Andromeda



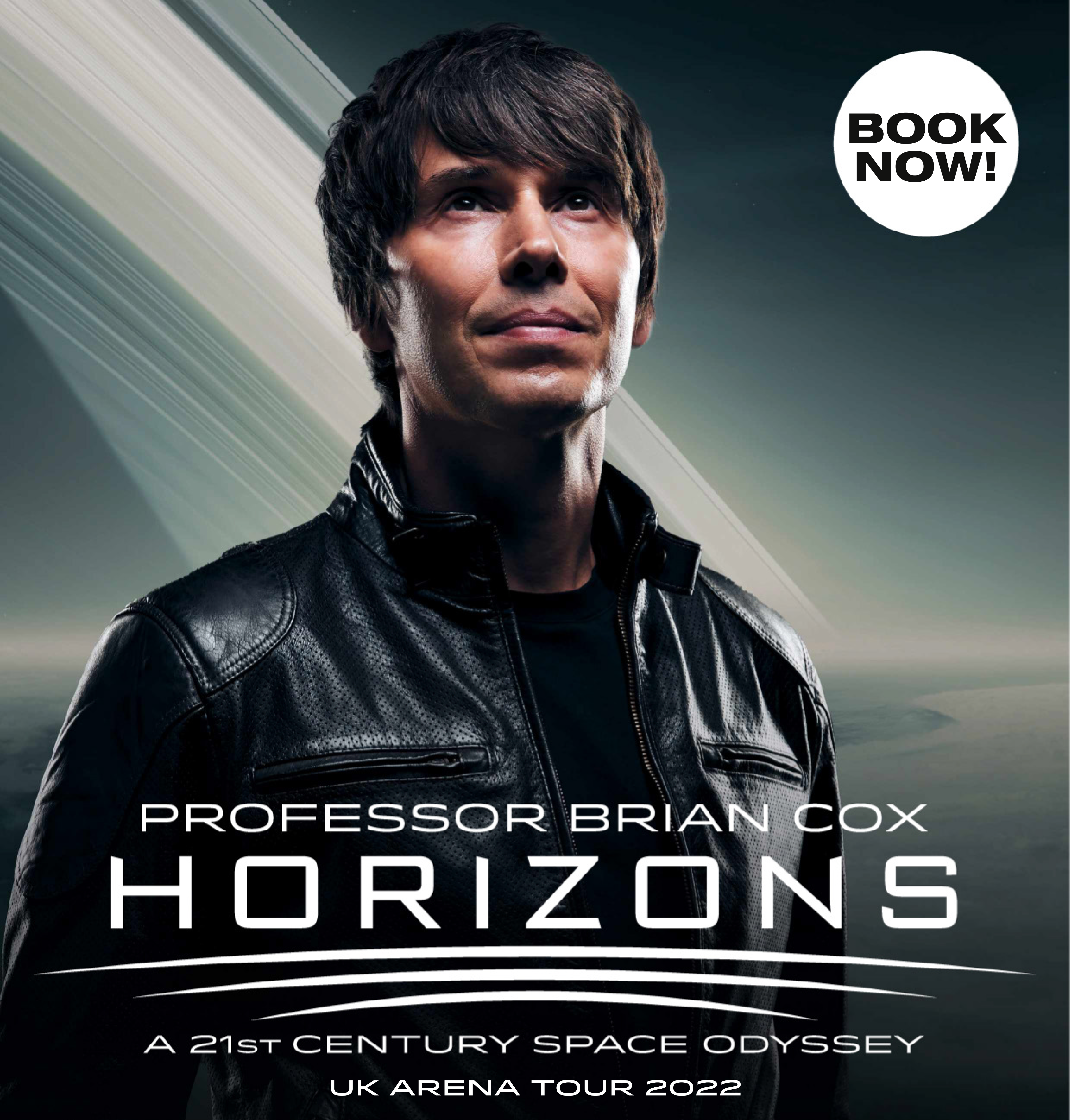
The faint smudge was found to be a galactic relic of the early Universe

A relic of one of the first ever galaxies has been discovered on the outer fringes of the Andromeda Galaxy.

The galaxy, called Pegasus V, was detected during the DESI Legacy Imaging Survey, a systematic search of Andromeda's dwarfs, but it was eagle-eyed amateur astronomer Giuseppe Donatiello that spotted a strange smudge in one of the images. Follow-up observations revealed this was a faint galaxy.

The stars of Pegasus V lack heavy elements, suggesting they first formed in the very early Universe, before later generations of stars seeded the cosmos with more elements.

"This discovery marks the first time a galaxy this faint has been found around the Andromeda Galaxy using an astronomical survey that wasn't specifically designed for the task," says Michelle Collins from the University of Surrey, who led the research. "We hope that further study of Pegasus V's chemical properties will provide clues into the earliest periods of star formation in the Universe. This little fossil galaxy from the early Universe may help us understand how galaxies form and whether our understanding of dark matter is correct."
www.legacysurvey.org



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15	**HULL**	Bonus Arena
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Our experts examine the hottest new research

CUTTING EDGE

An unknown object slams into Jupiter, causing the most energetic flash seen this century

Fireball over Jupiter outshines the Sun

The bright flash was caused by an impact the size of the Tunguska event

The spectacular collision of the comet Shoemaker–Levy 9 into Jupiter in 1994 was watched closely by observatories and space probes, and made headlines around the world. Since 2010, six impact flashes on Jupiter have been serendipitously observed, including by amateur astronomers. A simple brightness measurement allows for an estimate of the energy of such impacts, but far more accurate calculations can be made if they are recorded at several different wavelengths.

Ko Arimatsu, at the Astronomical Observatory, Kyoto University, and his colleagues have been using the Planetary ObservatioN Camera for Optical Transient Surveys (PONCOTS), dedicated to monitoring flashes on Jupiter. The system is made up of a 28cm Schmidt-Cassegrain telescope on a rooftop at the university, equipped with two CMOS cameras. This setup allows the astronomers to observe flashes on Jupiter at three different wavelengths simultaneously: the V visible band in the yellow and two near-infrared bands.

On 15 October 2021, Arimatsu and his team observed a particularly bright impact flash on Jupiter, occurring within the north tropical zone. The peak apparent brightness of the flash in the visible band was mag. 4.7, equivalent to an absolute magnitude of –29.0: roughly 300 times brighter than the Sun at Jupiter. And because their PONCOTS system can observe with a high frame rate across three wavelengths simultaneously, they were able to record this impact flash with unprecedented detail.

How big was the bang?

From the three light curves, they calculated that the temperature of the resultant fireball in the upper atmosphere of Jupiter was over 8,000°C. The impactor would have struck with a kinetic energy of around 7 million billion joules – an explosion equivalent to two megatons of TNT. This is comparable to that of the Tunguska event, when a meteoroid exploded over eastern Siberia in 1908 and flattened over 2,000 square kilometres of forest: the largest impact event on Earth in recorded history. From the energy of the Jovian impact, the impactor was estimated to have a mass of around four million kilogrammes and a diameter of 16–31 metres.

"The fireball was over 8,000°C. The impactor would have struck with an explosion equivalent to two megatons of TNT"

This is the most energetic impact flash observed in the Solar System since Shoemaker–Levy 9. Those created a string of giant dark patches in the Jovian atmosphere visible from Earth, scars that persisted for months. Arimatsu and his team were hopeful that their detected impact might also have left observable marks, but their follow-up observation 16 minutes after the event could find no signs. The Juno spacecraft, in orbit around the planet, was able to observe the impact site 28 hours later, but even with such a front-row view it too failed to spot any clear debris features. Arimatsu speculates that this could be due to the fact that their impactor was smaller than those of Shoemaker–Levy 9 and so any impact features were much more limited and shortlived.

Based on their observations, Arimatsu estimates that such Tunguska-like impact events on Jupiter occur roughly once a year – hundreds to thousands of times more often than on Earth – and so they're waiting eagerly to catch the next one!

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading… *Detection of an Extremely Large Impact Flash on Jupiter by High-cadence Multiwavelength Observations* by Ko Arimatsu et al. **Read it online at: https://arxiv.org/abs/2206.01050**

KO ARIMATSU, AGOR2012/ANASTASIIA_M/ISTOCK/GETTY IMAGES

Is ET phoning home?

Gravitational lensing could help boost extraterrestrial signals between the stars

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Where should we look for aliens? For more than 50 years, the usual answer has been 'among the stars', with the search for extraterrestrial intelligence (SETI) focused on scanning the skies with large radio telescopes. That might be changing, as a new generation of SETI experiments and scientists join the hunt.

Some want to look for alien artefacts in the Solar System, a plan sure to appeal to anyone who remembers *2001: A Space Odyssey*'s sinister black monolith. The trouble is that there is a lot of Solar System to investigate, and so it helps in your search if you have some idea of what the aliens might be up to.

The authors of this month's paper start with the idea that any alien probes that were exploring our neighbourhood would need to report back to their home system. Doing that, though, is hard, requiring what is presumably a modest probe to use an enormous amount of power to send a detectable signal over interstellar distances.

Any sensible alien spacecraft engineers would look for a shortcut. Luckily, they should know that radio waves, like any electromagnetic radiation, can be lensed and magnified by the Sun's gravity. Position a probe about 500 times the Earth–Sun distance behind the Sun, exactly in line with your home star, and it should be possible to get a report on Earth's status back home with transmitters not much more powerful than those our own spacecraft carry today.

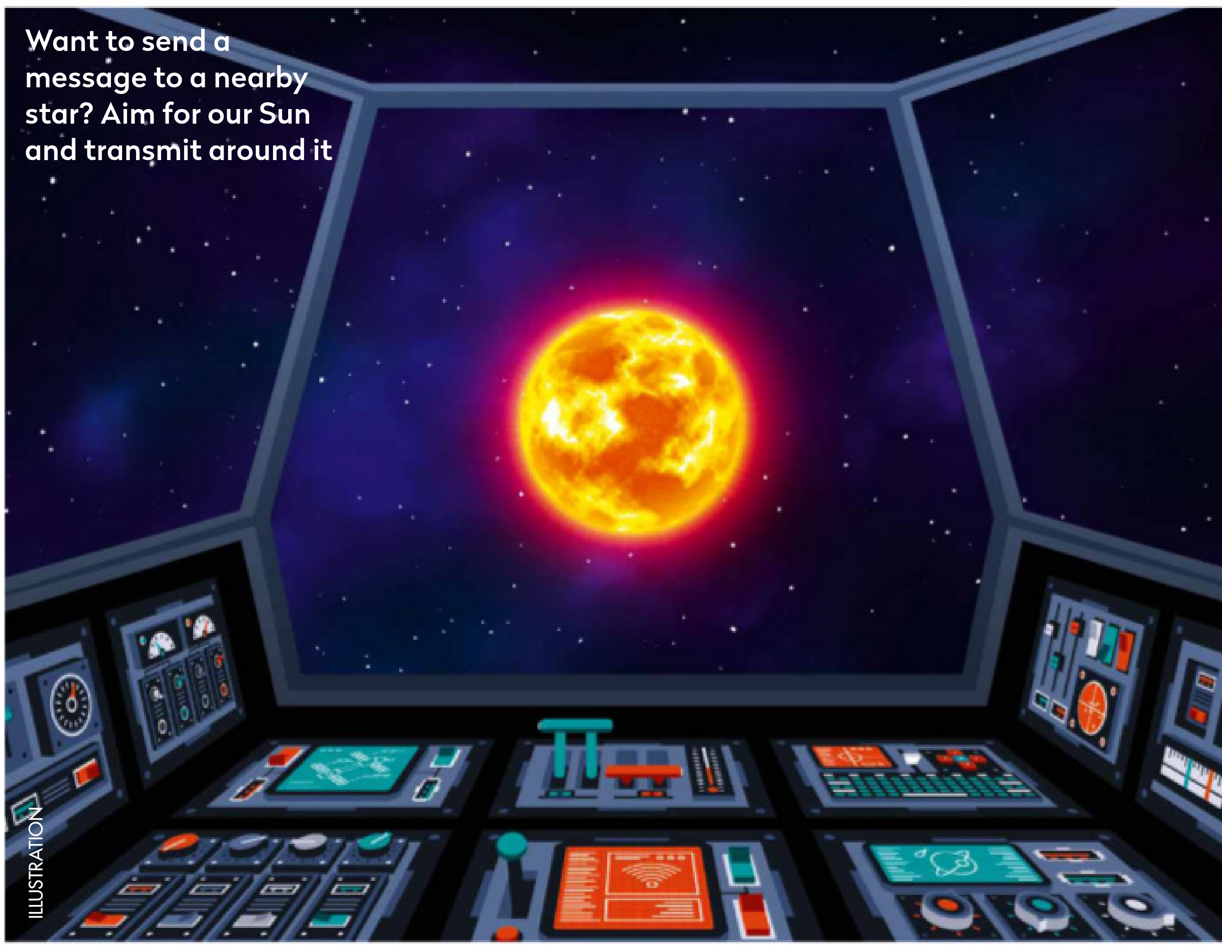
If we pay attention when Earth crosses the region between the Sun and a target star, looking for any stray signals with radio telescopes, we might be able to eavesdrop on their communications. This paper, the result of a summer project for some lucky undergraduates at Penn State University's SETI centre, used the Green Bank Telescope in radio-quiet West Virginia to do just that.

As ever with a SETI project, the biggest problem is distinguishing what might be an artificial transmission from all the noise and clutter generated by our terrestrial civilisation. In this case, we expect the source of a real signal to be close to stationary relative to the Sun, so we can pay attention only to those signals. A few candidate events are found in both the frequency bands that the astronomers targeted, but close inspection shows them to be false alarms. The brightest in a range of frequencies known as the L band, for example, seems to be chatter from an Iridium communications satellite.

Despite this non-detection, the technique has promise. After all, it's only one set of observations. Perhaps our beacon reports to the Alpha Centaurians only once a week, or once a year. Or perhaps Alpha Centauri is the wrong target.

"It's possible to imagine an interstellar communications network, with relay satellites positioned throughout the Galaxy"

It's possible, the authors say, to imagine an interstellar communications network, with relay satellites positioned throughout the Galaxy to forward messages via gravitational lensing. In such a system, multiple star systems like Alpha Centauri, with its two bright components plus faint Proxima, are poor choices, forcing their beacons to adjust position constantly as the stars move. Much better to look for signals pinging between nodes anchored on more boring stars – just like our Sun. We should probably keep looking.



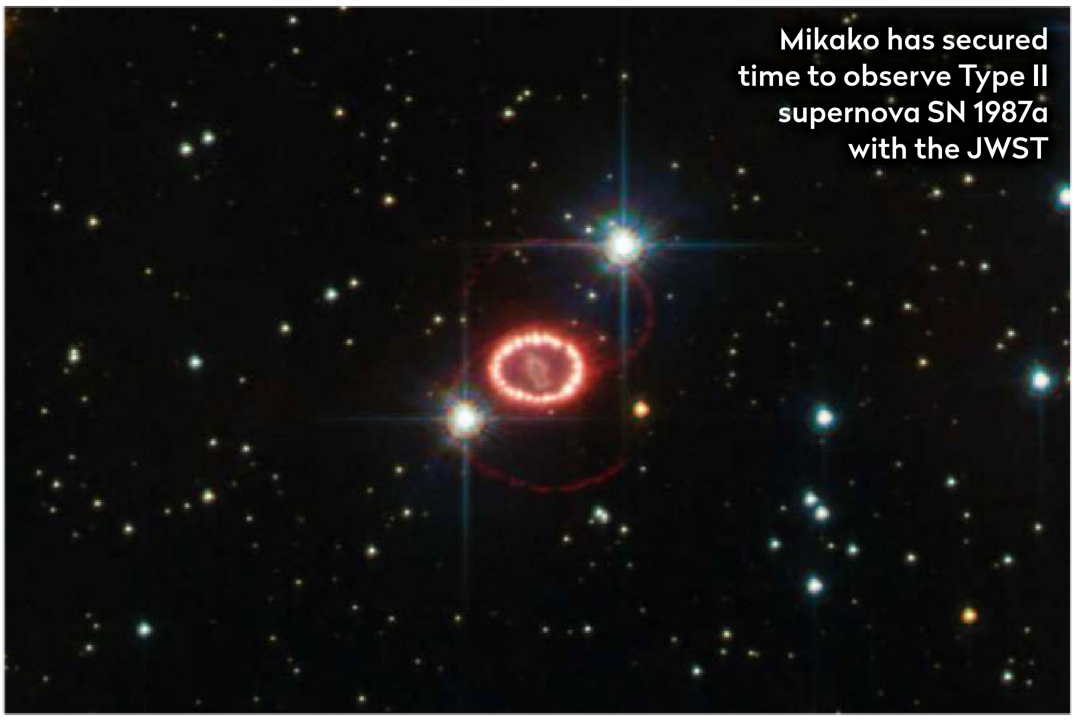
Want to send a message to a nearby star? Aim for our Sun and transmit around it

ILLUSTRATION

Chris Lintott was reading... *A Search for Radio Technosignatures at the Solar Gravitational Lens Targeting Alpha Centauri* by Nick Tusay et al
Read it online at: https://arxiv.org/abs/2206.14807

INSIDE THE SKY AT NIGHT

As the first images from JWST come in, **Mikako Matsuura** recalls how she won not just one but two observing opportunities on the world's most anticipated telescope



Mikako has secured time to observe Type II supernova SN 1987a with the JWST

With a mirror area 64 times bigger than NASA's previous infrared space telescope and instruments up to 100 times more sensitive, the James Webb Space Telescope (JWST) will allow us to take deeper and sharper images of astronomical objects than ever before.

Although JWST is a NASA-led mission with involvement from the European and Canadian space agencies, astronomers from any country can apply for observing time. When the call for proposals went out in 2018, I decided to request observations of Supernova 1987A. It's the closest supernova explosion in the last 400 years, located 170,000 lightyears away from Earth. We've been able to see the fast shock waves from the supernova, travelling at 1,000km/s, as they expand and destroy the surrounding material.

Writing an observing proposal is time-consuming. It takes up to two weeks, requiring detailed simulations of how much time is needed. But just as I finished writing the proposal and went to click the submit button, an e-mail from NASA arrived announcing the launch was delayed. How disappointing! JWST is a $10bn space mission, so of course it's better to be safe than sorry. But still, it was disheartening.

NASA reopened proposals two years later. When I looked back at my work, I realised it lacked a punchline: "Why do we need the JWST for this observation?" It's a key point that should be included in any observing proposals, but it was missing. I realised JWST will be able to capture how blast shock waves break up dust, which we couldn't see before.

Mikako addressing the International Astronomical Union in Brazil

Made it, with time to spare

Then, three days before the deadline, when everything was sorted, I realised something was wrong in my exposure time simulation. I started panicking, but it's always helpful to have collaborators. My colleagues Tea Temim and Martha Boyer from the Space Telescope Science Institute redid the simulations from scratch and we were able to submit on time.

Back in 2018, I'd also wanted to observe planetary nebula NGC 6302, but it would have been far too

The Butterfly Nebula NGC 6302 will be the target of her second study

THE SKY AT NIGHT WANTS YOUR QUESTIONS

As part of the British Science Festival 2022, *The Sky at Night* is recording a special programme on 14 September, when the presenters and special guests will be answering questions from viewers. If you have a question – on anything from space travel and technology to astronomy and astrophysics – the programme team want to hear from you at: **skyatnightqt@bbc.co.uk**

Dr Mikako Matsuura is an astrophysicist at Cardiff University working in infrared and millimetre observations

demanding to write two proposals. However, as I'd done most of the work for the Supernova 1987A submission back in 2018, I was able to write a new proposal for NGC 6302 in 2020.

It is always good to share ideas and get constructive criticism, and when I did, Rens Waters from Groningen and Eric Lagadec from Nice said, "It's a good idea, but there are too many details". Sometimes if you are in your own world, you don't really see your own faults: you lose the bigger picture. Rens re-wrote the first key introduction paragraph, guiding the scientific case, and so the second proposal was submitted.

Another six months passed. It was April 2021, a sunny day just before Easter. My husband and I took an extra day off and went for a drive when suddenly my phone notified me the JWST selection results were out. I was so scared to open the emails, not knowing if they would say "Congratulations!" or "We're very sorry".

After I came back home, I took a breath and opened them. *Both* were accepted. Unbelievable! At the same time, the responsibility to make these observing programs successful now fell on my shoulders. And now, as the data arrives, it's time for the next round of challenges to begin.

Looking back: The Sky at Night

19 September 1957

On 19 September 1957's episode of *The Sky at Night*, Patrick Moore was joined on the show by a special guest: 14-year-old astronomer Clive Hare. On 3 August, Hare had been one of the first people to observe a new comet streaking across the sky in the constellation of Gemini. Being a member of the British Astronomical Association, Hare knew to report his findings, noting that the comet was of equal brightness to nearby Pollux (mag +1.5) and around 2° long.

▲ Young astronomer Clive Hare tells Patrick Moore about his sighting

As the BAA raced to release a report, it soon became clear that astronomers all over the world were also making the same discovery. The first sighting was traced back to Japanese astronomer S Kuragano on 29 July, but several other astronomers also spotted the comet. In the end, naming rights went to the first report to reach the International Astronomical Union, which was from Czech astronomer Anotonín Mrkos. Now the comet is known as Comet C/1957 P1 Mrkos. It would eventually reach a brightness of mag. +1.0 on 4 August and stretched out across 5° of sky at its longest. After that, the comet slowly faded, passing through the constellation of Ursa Major to Coma Berenices, and was eventually lost from view in Virgo at the end of September.

Hare's appearance on the show was part of Patrick's lifelong belief that anyone could be an astronomer, regardless of age, and his observation remains a prime example of the major role amateur astronomers play in the world of astronomical discovery.

The Sky at Night SEPTEMBER

How to Photograph the Universe

So you enjoy observing the night sky, watching the planets, stars and other objects through your telescope, but have you ever wanted to photograph what you see? In this month's episode, Pete Lawrence is your guide as he and the team explore astrophotography: what you need to get started and how you too can capture beautiful images of the cosmos.

BBC Four, **12 September**, 10pm (first repeat will be on BBC Four, **15 September,** time tbc) **Check www.bbc.co.uk/skyatnight for up-to-date information**

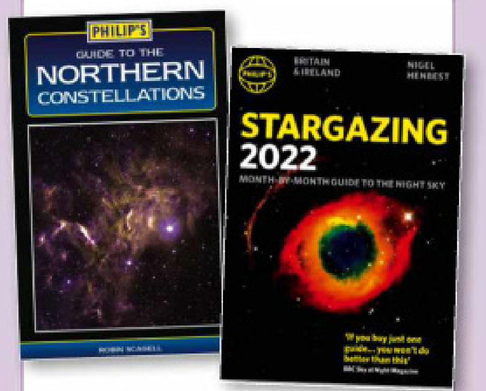
▲ Find out how you can get started in astro imaging in this month's episode

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles



The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Making good times with a DIY sundial

Thank you very much indeed for publishing Mary McIntyre's instructions for making an equatorial sundial (DIY Astronomy, 'Make a paper equatorial sundial', August 2022 issue, page 74). The timing was perfect as I needed to occupy my granddaughter Akira on the first day of the summer holidays. It proved to be a tremendous learning exercise for both of us and we were delighted when the Sun came out just before Akira's bedtime and correctly showed the time as almost 6pm GMT (7pm BST – or bedtime). The next job is to build a weatherproof version for the garden!

Peter and Akira Bartram, via email

We're delighted to see the sundial in action, Peter and Akira, and providing the timing for important points in the day like bedtime! It's a great little project this one, easy to do and a fun activity for all ages. ***– Ed.***

▲ Akira's paper and drinking straw timepiece

Tweet

Cath Adams
@CathAdams1973 • Jul 19
@skyatnightmag I've been sitting outside stargazing, the air is cooler but sadly no breeze. Here is the International Space Station passing over my house at 23:06 taken using @NightCapApp on an iPhone. #InternationalSpaceStation

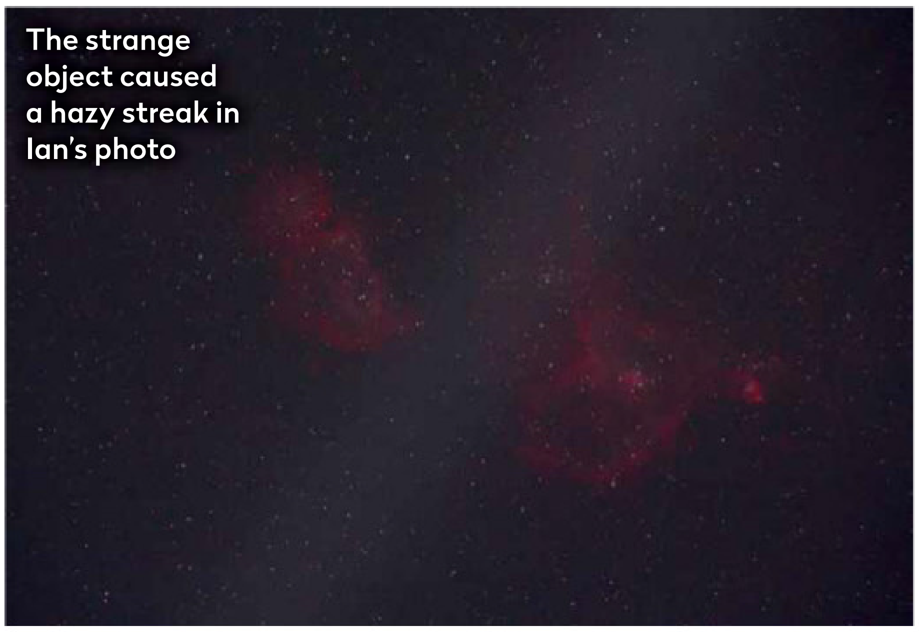
Number crunching

Thank you for all you are doing for a great and long-lived magazine. In July's book reviews section, I was interested to read that author Antonio Padilla calculates the biggest number in the Universe to be 10^{61} (review of *Fantastic Numbers and Where to Find Them*, page 94). In my forthcoming book on the history of Greek astronomy, *A String of Pearls*, I summarise Archimedes's calculation of the size of the heliocentric Universe, and follow up by looking at this brilliant mathematician's zest for exploring even larger numbers. Not content with numbers restricted to the size of the Universe, Archimedes continued to construct a perfectly logical counting structure that soared way beyond human imagining until he finally decided to call a halt when he reached $10^{80,000,000,000,000,000}$ (converted from Greek to our numeration)! A listing of Archimedes's values for interplanetary distances has come down to us, but unfortunately through a garbled secondary source.

Paul Mohr, Corrandulla, County Galway, Ireland

Mystery object

I was wondering if you could help me to identify something in the night sky on Friday 29 April at 23:07pm. I've tried to do my own research but nothing conclusive has materialised. It travelled south to north, looked like a small, spherical white full Moon, but was hazy in its appearance (its core was brighter). I tracked it from overhead until it disappeared below the horizon line. I was taking shots of the Heart and Soul Nebula and found out the following morning that this object passed right through one of the images. The



photos were taken in Wales. I've seen and imaged many a shooting star and the ISS but never seen anything as large as this. Any ideas? Thanks.
Ian Sutton, via email

This was the deorbit burn of a Russian Angara 1.2 rocket stage launched earlier that evening. Nice catch, Ian! ***– Ed.***

Moving picture

I am puzzled and would be grateful if someone could answer a question for me. According to the television reports, the images that we have seen from the James Webb Space Telescope include some galaxies that are about 13 billion years old. I assume that these galaxies are not stationary and while the light from them has been travelling towards us, the galaxies themselves have moved and are thus today no longer where they appear to us to be. But if we are seeing them where they were shortly after the Big Bang then why are they all so far apart? Why aren't they clustered together, relatively speaking, near to the centre of the event?
Dr Giles Camplin, council member of the Airship Association, London

The current theory to explain why objects like galaxies were ▸

ON FACEBOOK

WE ASKED: what do you think of JWST's new image of Stephan's Quintet (see page 9)?

Tim Jardine A galaxy group I have viewed and imaged many times, but to see it like this is just amazing.

Jon Mcinerney You wait 13 billion years, and then five galaxies turn up at once.

Linda Wood Field I think it's amazing and beyond comprehension.

Michael Page You get different information when viewing the Universe at different light wavelengths. Infrared light can pass through the gas and dust clouds that Hubble can see in visible light, so Webb allows the scientists to see the objects that are inside or behind those dust clouds.

Frank Michael Knight Game changing for the future of science. Truly stunning.

Lindy Lou Looks like part of a paw.

Peter Parr Gotta be intelligent life out there.

Jason Philip Hall Astonishing! Pure and simple. This instrument will change everything.

Ed Shendell Absolutely amazed at the images coming from the James Webb Telescope. Looking back in time 13.5 billion years ago! The impact this will have on locating lost luggage cannot be underestimated.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

Should I insulate my observatory?

KEVIN PRIOR

Mitigating the effects of large temperature fluctuations to aid cooling down times and reduce the problems of dew formation are excellent reasons for installing an observatory. But a bare observatory won't solve these issues completely, so it is worth making it as temperature-stable as possible.


BARRY WILSON

▲ **A wooden roll-off-roof observatory is easier to insulate than a metal-domed structure**

Wooden roll-off-roof designs are much easier to insulate than metal or fibreglass domed observatories, and wood construction already offers an advantage in temperature stabilisation. However, there is an argument for not using additional insulation as this could lead to heat retention, which is radiated later in the day causing unwanted air currents that can spoil the view. You can avoid this by opening up the observatory earlier, in advance of an observing session.

For a roll-off-roof design, a combination of insulation and good ventilation is likely to be a good solution and a pale-coloured (ideally white) domed observatory with good ventilation will also yield good results. Either solution will benefit greatly from the use of a desiccant dehumidifier.

Steve's top tip

How do I set up a finderscope?

A finderscope is a small, wide-field scope that helps you find targets in the night sky. It should be firmly mounted to the main telescope tube, normally using a small dovetail bar. Finderscopes should be accurately aligned with the telescope in two stages. Start by pointing the telescope at a distant object during the daytime (NOT the Sun), and centre it in the eyepiece. Next, without moving the telescope, centre the same object on the finderscope's crosshairs by adjusting the three adjustment screws. To align at night, centre a bright star in your eyepiece, then centre the same star on the finderscope's crosshairs using the screws on its mount.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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▸ already so far apart so soon after the Big Bang is called Inflation. It proposes a period of immensely rapid, exponential expansion in the Universe during its first few moments. ***– Ed.***

Room to grow

I have a question about the expanding Universe, which I haven't seen an answer to yet. If the Universe is expanding, where is it expanding to? Is there something outside the Universe as well? Surely it cannot expand into nothingness. If there is something outside the Universe, is it possible that it's another Universe?
Tivadar Tot, Serbia

We're not entirely sure, but the leading idea is that it is expanding into dimensions we can't perceive. Imagine a person living in two dimensions on the surface of a balloon that's inflating – they can see the space around them getting larger, but not the third dimension it's expanding into. ***– Ed.***

Force fault

In the article 'Jupiter's Asteroid Swarms' (July 2022 issue, Cutting Edge) it states that, "the gravitation of the Sun pulling in and the centrifugal force of our motion flinging out act to balance each other out". As a physics graduate and teacher, I know that this statement is incorrect. There is no such thing as 'centrifugal force'. Our planet stays in orbit due to the gravitational force towards the Sun providing the 'centripetal' force required for the Earth to follow its orbit. This force is not balanced by any other force, and indeed is an unbalanced force. If this force was not present, the Earth would merely continue in a straight line at a constant speed.
Steven Mitchell, via email

While centrifugal force is an 'apparent' force, which doesn't actually exist like centripetal force does, astronomers use it as a common short-hand as it's an easily understandable term. ***– Ed.***

Instagram

photoknoxy • 15 July

Another view of Wednesday's rising full Moon (aka the 'Buck Moon' or supermoon) with the ruins of Mow Cop castle silhouetted in the foreground. #cheshire #fullmoon #moonrise #buckmoon #lunarphotography #nightsky #bbcnorthwest @bbcskyatnightmag @canonuk @ nationaltrust @bbcnorthwest

SOCIETY IN FOCUS

York Astronomical society (YAS) was pleased to celebrate its 50th anniversary this year, and we're looking forward to continuing our success with a series of events planned for this autumn.

YAS was founded in 1972 in response to the excitement generated by the Apollo programme. In April that year a group of observers from Stamford Bridge formed the society, initially meeting at their local pub or a garage belonging to one of the members. Later meetings were held at York Railway Institute, where two rooms with open coal fires and large tables were on offer. Discussions included the 10 November 1973 Mercury transit and Comet Kohoutek. One of our first observatories was in a derelict brick building, part of the abandoned hospital site on the edge of Acaster Aerodrome dating from WW2. We enjoyed camping there and using the old telescope, fortified by runs to the chip shop and the pub! In the last 50 years we've had six observatory sites and five different meeting places. Today we have an observatory at a farm east of York where we hold meetings and public events.

▲ YAS observatory in 1978

Extract from *The Definitive History of the York Astronomical Society (So Far!)*, by Martin Dawson
▸ **yorkastro.org.uk**

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Discovering and Imaging Planetary Nebulae

Augustine United Church, Edinburgh, 9 September, 7:30pm

Join the Astronomical Society of Edinburgh for a talk on why these dying stars are of such interest to cosmologists, and how you can go about observing and imaging them for yourself.

www.astronomyedinburgh.org

Astronomy Festival

Observatory Science Centre, Herstmonceux, E Sussex, 2–4 September

A weekend under the stars, featuring stargazing evenings with telescopes large and small, plus lectures, planetarium shows, solar observing, trade stands and a pub quiz. Tickets from £11.50.

www.the-observatory.org/events

Super Telescope: Mission to the Edge of the Universe

Online

This *Horizon* documentary explores the inside story of the James Webb Space Telescope. **BBC iPlayer**

Stargazing session

Durlston Country Park, Swanage, Dorset, 4 September, 8:15pm

Join the astronomers from the Wessex Astronomical Society for an observing session at their fantastic observatory located in Durlston Country Park. This event includes observing the Moon, Jupiter, Saturn and summer constellations. A small fee is payable.

wessex-astro.org.uk

RICHARD JUDD, FRAS, CHRISTOPH KALTSEIS/CCDGUIDE.COM

PICK OF THE MONTH

▲ ***The Sky at Night*** **presenter Chris Lintott's talk is open to the public and new members**

How to be Surprised by the Universe

Clanfield Memorial Hall, near Portsmouth, 9 September, 8pm

Astrophysicist and *The Sky at Night* presenter Chris Lintott will be delivering a talk entitled 'How to be Surprised by the Universe' to the Hampshire Astronomical Group at the Memorial Hall near its Clanfield Observatory (above). Situated on the edge of the South Downs National Park, the group was founded in Portsmouth in 1960 but work didn't begin on the observatory until 1972. From mysterious radio signals to spectacular supernovae, the Universe keeps finding new ways to astonish us. Chris Lintott of the University of Oxford explains why we should keep our eyes peeled for the unusual, and what to do when you think you've found an alien civilisation. Entry £3 for non-members. **hantsastro.org.uk**

Stargazing weekend

Island Planetarium, Yarmouth, Isle of Wight, 23–25 September

This weekend includes evening stargazing, daytime observations of the Sun, visits to the observatory or Needles Battery Space Display, plus talks and teaching sessions. £75 per person.

www.islandastronomy.co.uk

Brecon Dark Sky Festival

Brecon Beacons, 24–25 September

Enjoy planetarium shows, stargazing, telescope observing and paddle boarding under the stars in one of the world's best dark-sky regions. Events individually priced, ranging from free to £10.

www.breconbeacons.org/stargazing

Herschel 200

Herschel Museum of Astronomy, Bath, until 31 December

A major exhibition brings new collections to the Bath home of celebrated 18th-century astronomer William Herschel for the 200th anniversary of his death. Adult tickets £9.50, kids' tickets £4.50.

www.herschelmuseum.org.uk


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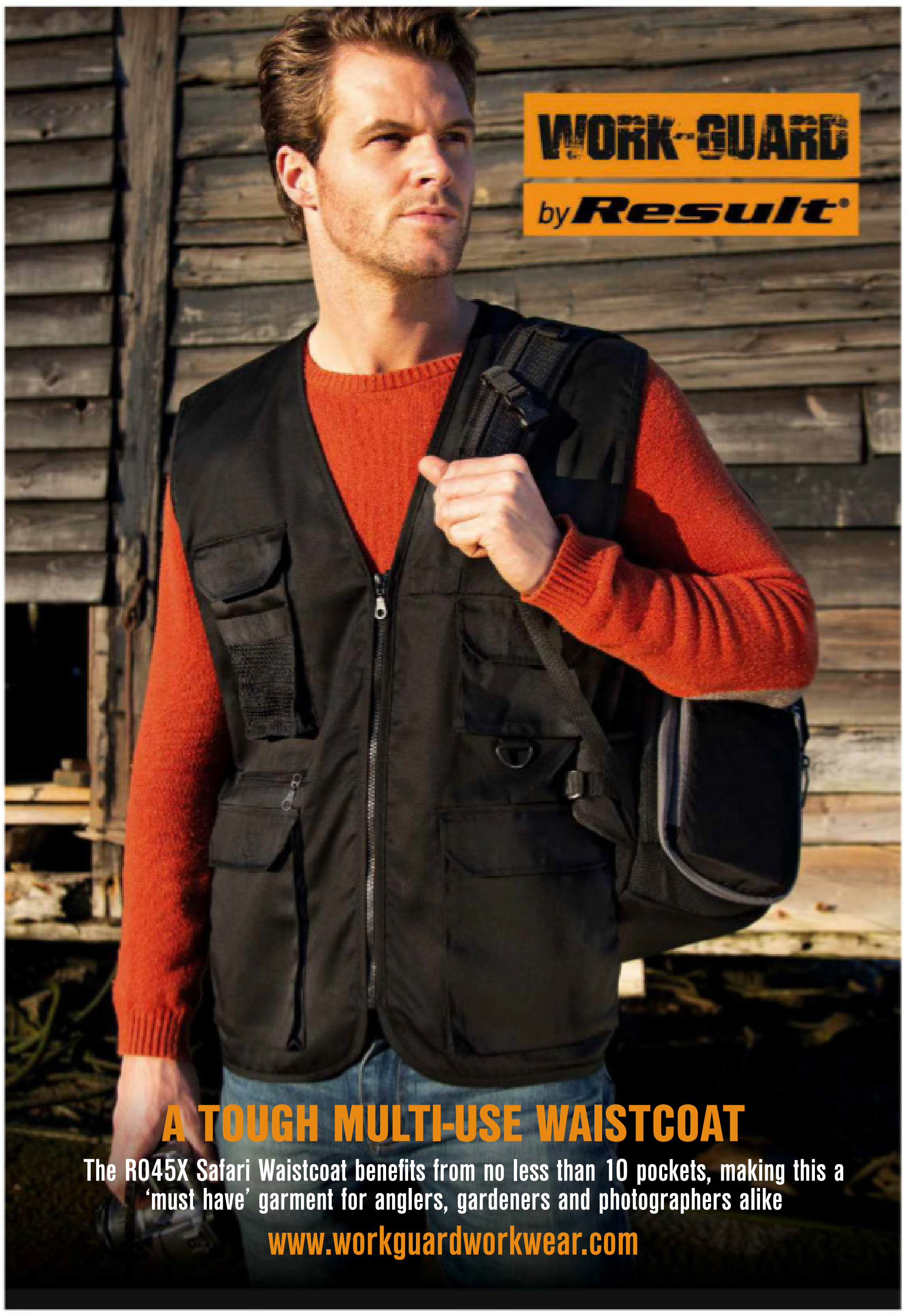
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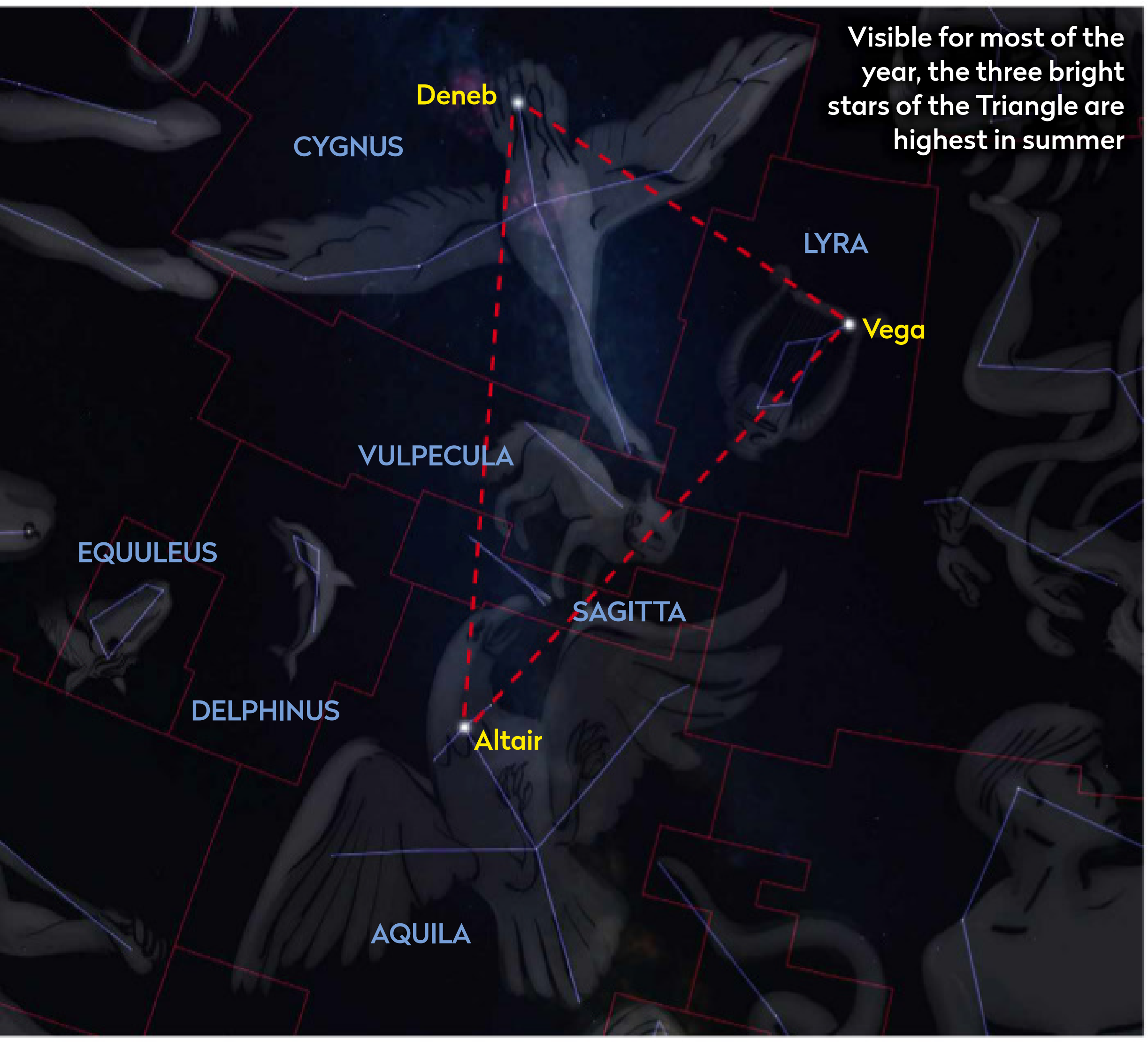
FIELD OF VIEW

An ode to the Summer Triangle

Scott Levine has a soft spot for the superstar asterism of the warmer months



Visible for most of the year, the three bright stars of the Triangle are highest in summer


Scott Levine is a naked-eye stargazer and an astronomy writer based in New York's Hudson Valley

On a breezy night when I was still new to my neighbourhood, I slipped out into the dark, stumbled to my favourite north-facing spot and looked up. My hopes for quiet were dashed when my chatty neighbour joined me, but as early-season crickets chirped, we shifted our gaze between branches, stared into one of my favourite patches of the sky and talked about the stars, and about nothing.

Growing up in a dense suburb, not far from a rail station and small airport, the Summer Triangle asterism was one of the few groups of stars that pierced the sky-glow enough that I could see it easily. Its corner stars are among the night's brightest, but the shape they sketch is compact and sleek, like a sensible sedan car. I've loved it ever since. Blue-white Vega (Alpha (α) Lyrae) arrives just above the northeast horizon in mid-May, with Deneb (Alpha (α) Cygni) and Altair (Alpha (α) Aquilae) close behind.

As the weeks passed, I ran into that same neighbour from time to time. Stars rise four minutes earlier each night, which doesn't seem like much, but little by little these minutes add up. By August, as we talked about racing from work to soccer games, then home to get dinner on and off the table, the Triangle rose up to where it might be easier – and safer – to lie on our backs in the street than to twist our necks to find it. It would be January before the minutes carried those stars out through the western dusk.

Altair and Vega are just across town as things go: only about 16 and 25 lightyears away, which helps them appear unusually bright in our sky. Deneb, though, is more challenging. It's one of the most distant star systems we can see with our unaided eye: over 2,000 lightyears away. So it's not near the others at all, but far behind them. The Deneb we see is much more subdued than Altair and Vega. If we're able to see it so brightly from so far away, imagine what it would be like if it were much closer.

Let's consider the other stars within and near the Triangle: the unlabelled, understated, anonymous stars. Other than Vega, all of the constellation Lyra's stars are dim, as are those in Vulpecula (the Fox), Sagitta (the Arrow), Delphinus (the Dolphin) and Equuleus (the little horse), the group of small constellations that carve a path through the Triangle. These stars are all listed and catalogued, but many aren't named. I love to look up and think about what's out there – not just what we know, but also what we don't – and imagine what we'll learn one day.

In dark-sky places, far behind Deneb, we can even see the soft glow of countless stars running through the Triangle, their light blurred together by many thousands of empty lightyears: the band of our Milky Way Galaxy.

As those early few weeks turned into years, and toddlers turned into teenagers, those moments with neighbours were some of my favourite times. My friend has since moved away, but you never know who you might run into tonight when out under the night sky. I hope you'll look up… and try not to hurt your neck.

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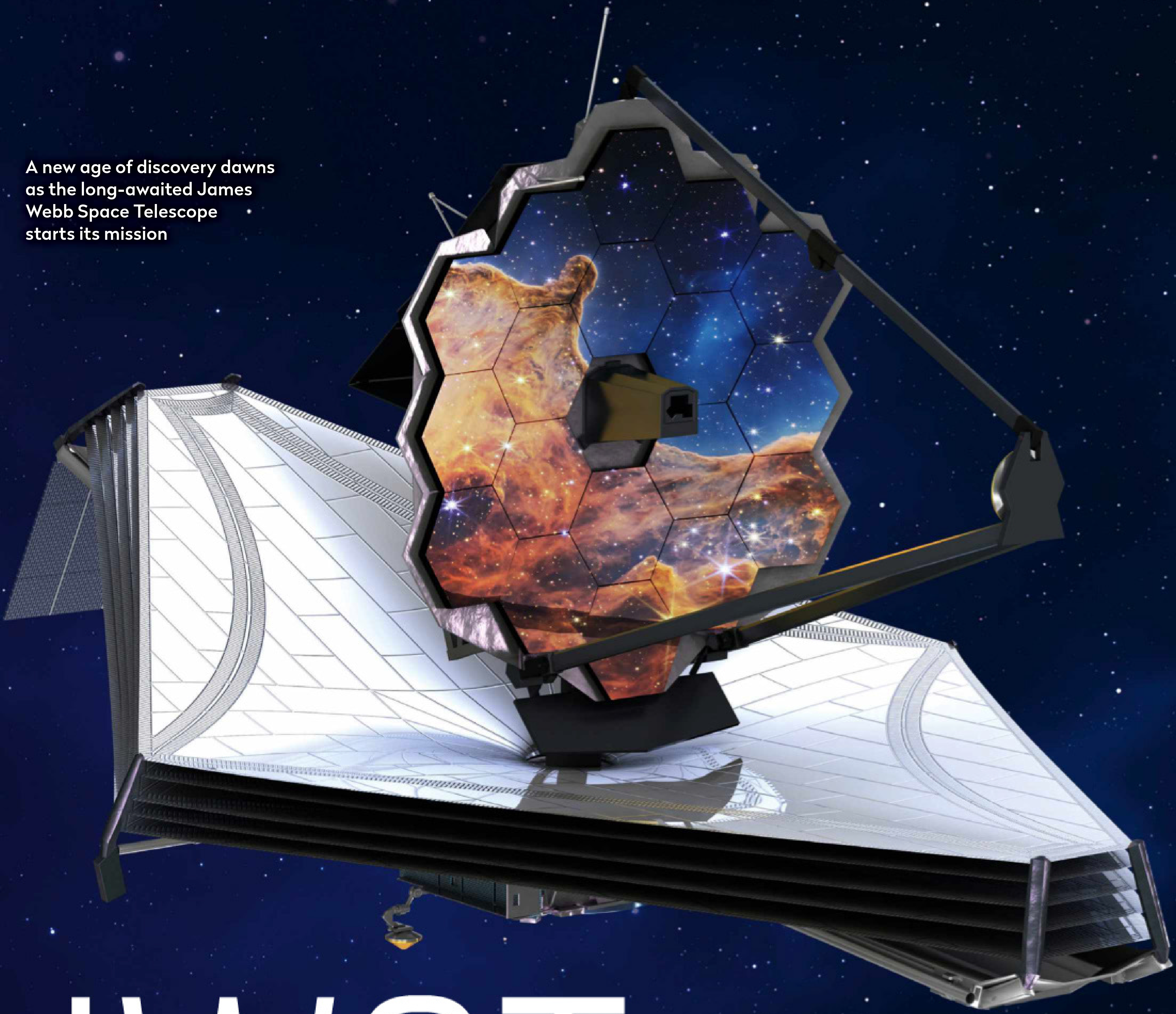
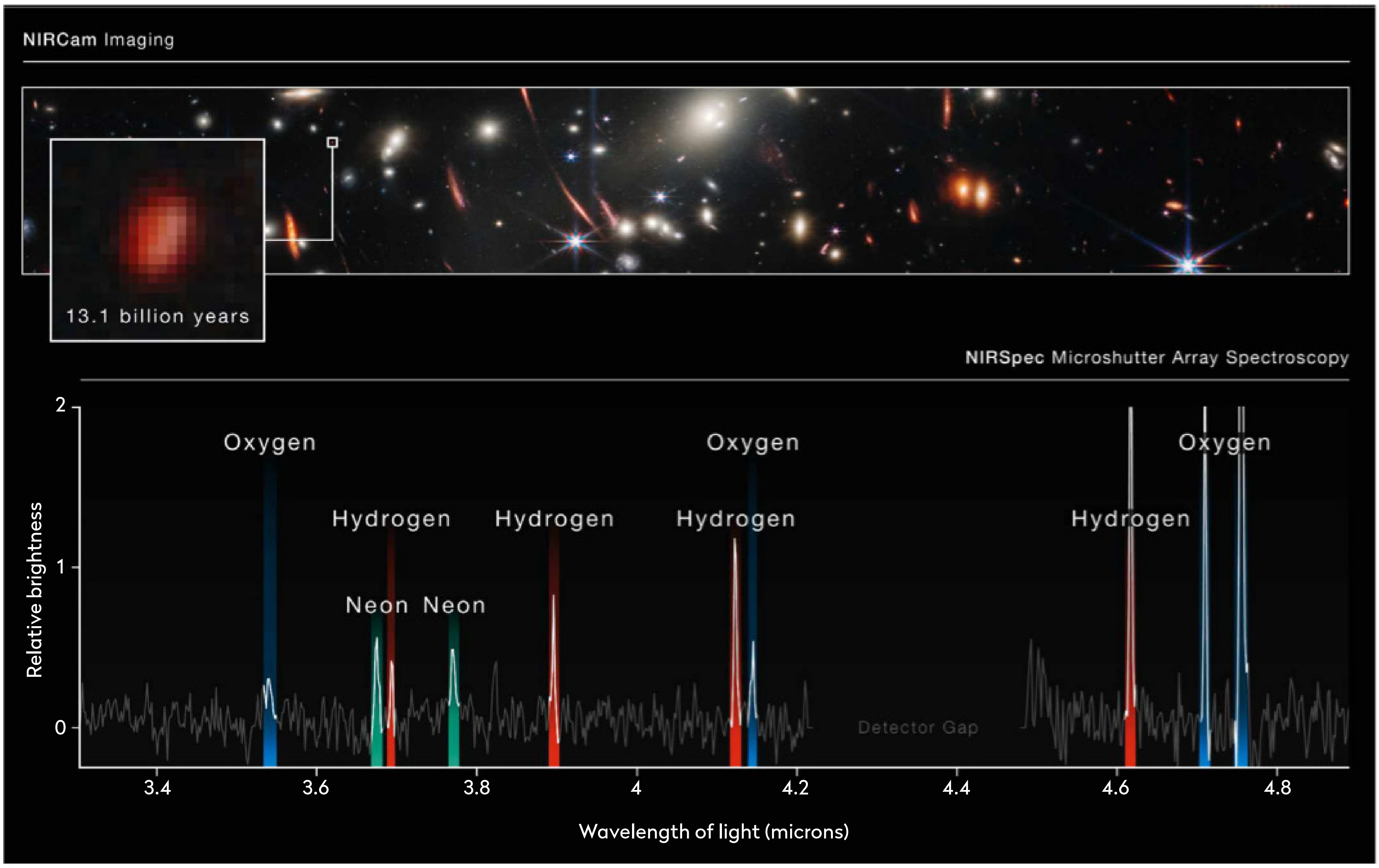
A new age of discovery dawns as the long-awaited James Webb Space Telescope starts its mission



JWST begins its SCIENCE JOURNEY

As we gaze astonished at the James Webb Space Telescope's first science images, **Colin Stuart** takes a look at the questions it will answer over its decade-long voyage of astronomical discovery

Colin Stuart (@skyponderer) is an astronomy author and speaker. Get a free e-book at colinstuart.net/ebook



▲ **A single galaxy 13.1 billion years old is picked out of a field of hundreds and its light signature recorded by Webb's NIRSpec instrument, a tool so sensitive it can mine information simultaneously from up to 150 individual galaxies that existed in the very early Universe**

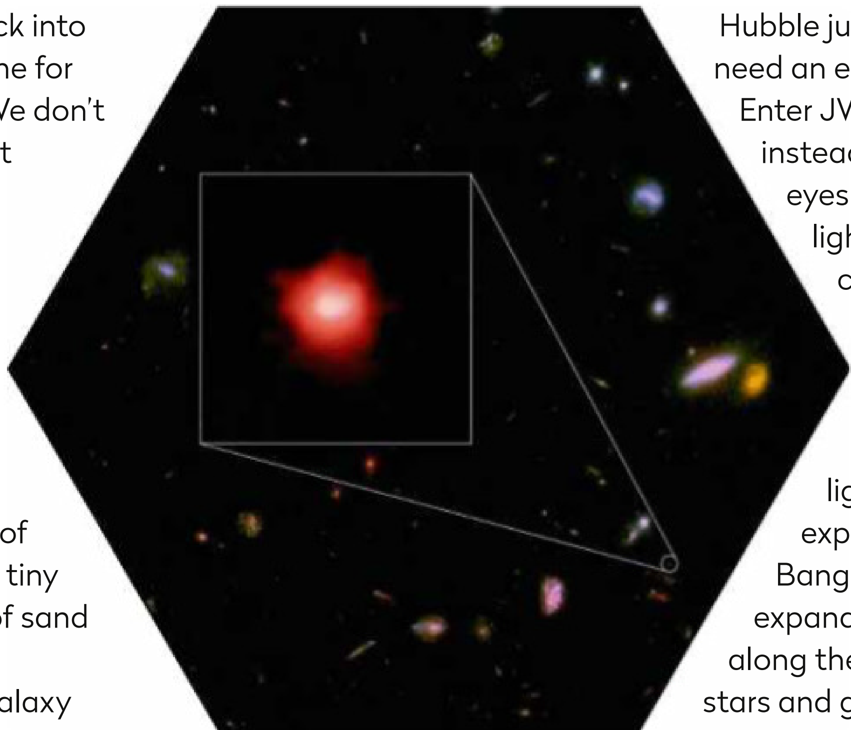
What do the first stars look like?

JWST will take us back to when the very first galaxies appeared

Astronomers are always looking back into the past. That's because it takes time for light to travel across the Universe. We don't see things as they are when the light arrives here, but as they *were* when the light first departed. For distant galaxies, the delay is millions and even billions of years.

So very distant galaxies were also some of the first galaxies to form in the Universe. The Hubble Space Telescope revolutionised this area of research, finding thousands of distant galaxies in a patch of sky so tiny that it could be covered by a grain of sand held at arm's length.

The light from the most distant galaxy observed before JWST – HD1 – took a staggering 13.1 billion years to reach Earth. Astronomers are peering back to a time just 700 million years after the Big Bang. Yet they want to look back even further to when the very first stars and galaxies appeared, estimated to be 100–200 million years after the Big Bang. They're hunting the first light that lit up the so-called cosmic dark ages.



▲ **Right out of the gate, JWST has found the oldest galaxies ever seen, like GLASS-z13 (above), 13.4 billion lightyears away**

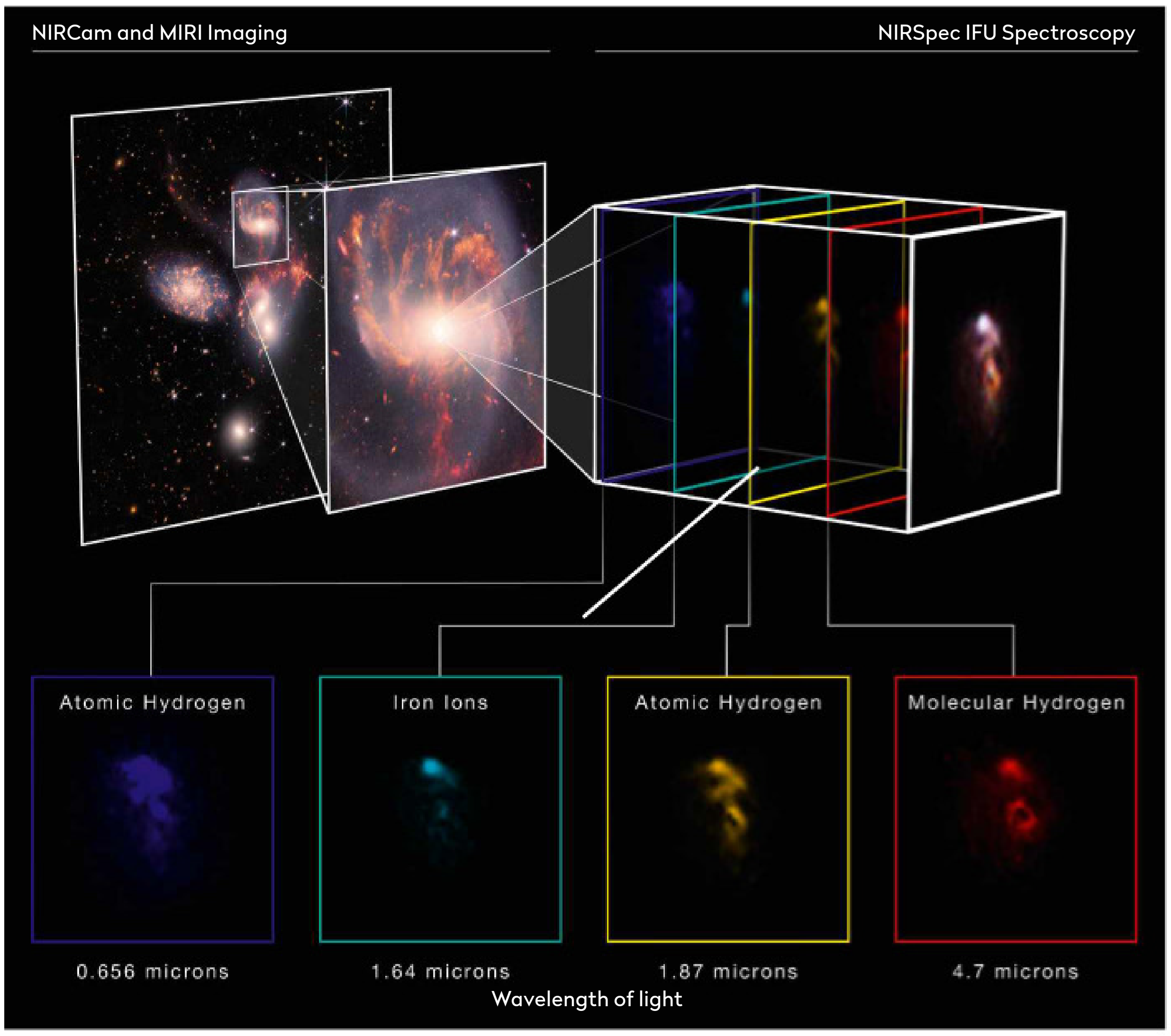
Hubble just isn't up to that task – you need an entirely different kind of telescope. Enter JWST, which gathers infrared light instead of the visible light to which our eyes, and Hubble, are sensitive. Infrared light is able to penetrate the dust that can sometimes block our view of distant galaxies.

For the very first galaxies, there's an even more fundamental problem with observing in visible light. The Universe has been expanding ever since its birth in the Big Bang. Any light travelling through the expanding Universe also gets stretched along the way. The light from the earliest stars and galaxies has been stretched so much that it's now slipped out of the visible spectrum and into the infrared. Now, for the first time, we'll be able to see it.

"It's a chance for scientists to find out what typical galaxies were like in the very early Universe and maybe even find evidence of the very first stars ever formed," says Dr Emma Curtis-Lake, STFC Webb Fellow at the University of Hertfordshire. ▸

How do galaxies form?

JWST will show galaxies evolving, from billion of years ago up to today



◄ **The gas around a black hole within Stephan's Quintet, its elements revealed by the telescope's NIRSpec instrument**

We live in the Milky Way galaxy – a vast stellar metropolis containing up to 400 billion stars. In turn there are up to two trillion other galaxies in the Universe. But how are these vast structures made? Most astronomers tend to favour a so-called 'bottom-up' approach in which a galaxy forms from a series of mergers involving smaller groups of stars. Yet it is far from clear exactly how this process plays out. Thankfully, JWST can help.

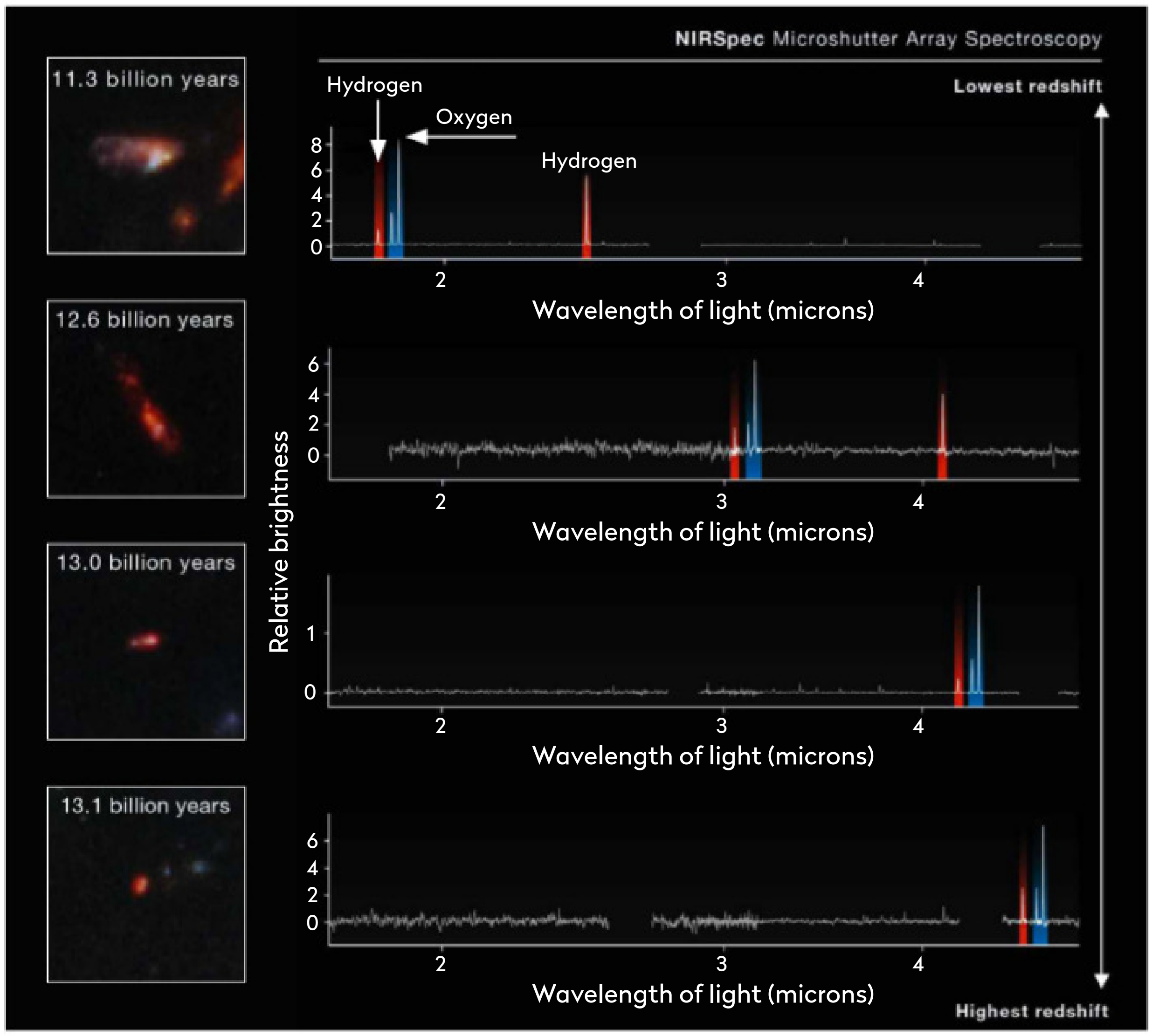
One of the early images from JWST depicts Stephan's Quintet, a collection of five galaxies, four of which are interacting with one another. It shows us that a gravitational dance is underway as dust, gas and stars pirouette, pulled around by each other's gravity. One of the galaxies – NGC 7318B – is producing huge shockwaves as it careers through the cluster. While the four interacting galaxies are relatively close to us at just under 300 million lightyears, studying them will help astronomers understand what they're looking at when they turn JWST towards more distant galaxies.

One instrument aboard JWST is particularly well suited to this endeavour: the Near-Infrared Spectrograph (NIRSpec).

Astronomers have already pointed it towards the supermassive black hole in the centre of one of four interacting galaxies in Stephan's Quintet – NGC 7319. Black holes are thought to play a significant role in galactic evolution. The one in NGC 7319 has a mass equal to 24 million Suns, a number so big that it could only have formed by the mergers of lots of smaller black holes.

The instrument has also been deployed further afield. "My favourite moment [from the first JWST data] was when they revealed the image showing the NIRSpec spectrum of a galaxy over 13 billion lightyears away," says Curtis-Lake. "I've been impatient to find out how NIRSpec performs, and I can't wait to get my hands on it and test our models for my own research," she says.

NIRSpec can simultaneously observe hundreds of galaxies at once, looking for evidence that mergers are taking place.



▲ **Emission lines never previously seen at such immense distances: even a quick analysis showed that galaxies in JWST's first deep field (see page 8) were the oldest ever discovered**

NASA/ESA/CSA/STSCI X 3, NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

How are stars and planets born?

JWST will pierce the dust clouds to show us how worlds are made

The modern world offers people many ways to look back on what we were like as children. It isn't so easy with stars. Our Sun is in its middle age at 4.6 billion years old, but astronomers have found some stars that are just one million years old – that's the equivalent of being a 3.5-day-old baby in human terms.

Among the first images to be returned by JWST is a stunning look at the Carina Nebula, a cloud of gas and dust where hot young stars are bursting into life. These stellar infants are enshrouded by dust, which obscures the view that visible light telescopes such as Hubble can see, but which JWST pierces straight through. The infrared reveals hidden stars, allowing astronomers to see how their radiation carves through the surrounding gas.

The telescope will also be able to look at the planet-forming regions around stars. The outer parts of these protoplanetary discs have been studied before using radio telescopes such as the Atacama Large Millimeter Array (ALMA) in Chile. However, JWST's greater resolution will mean it can peer into the inner part of the disc where rocky Earth-like planets may be forming.

JWST will measure the different types of molecules present in the inner disc such as water, carbon dioxide and methane – all associated with life in some way. If, for example, water is already present in and around newborn rocky planets then that has promising implications for our chances of finding water worlds elsewhere in the Universe.

Astronomers have already been surprised by the variety of distant planets they've found to date. Many stars are orbited by so-called super-Earths and mini-Neptunes – worlds partway in size between the Solar System's rocky and gas planets. They seem to be the most common type of planet in the Universe and yet there are none in our own Solar System. JWST could help us learn what these planets look like and how they come about.

Many of these observations can only be made in the infrared, which is absorbed by Earth's atmosphere. It's why these measurements require a space-based telescope. JWST is also positioned 1.5 million kilometres away from Earth to avoid contamination from the infrared energy emitted by Earth itself, giving it the clear view it needs to pick up such miniscule detail from lightyears away. ▸

▾ The penetrative power of JWST's infrared is starkly revealed in this comparison of the star nursery in the Carina Nebula (left) with the image taken by the Hubble Space Telescope in 2008 (right)

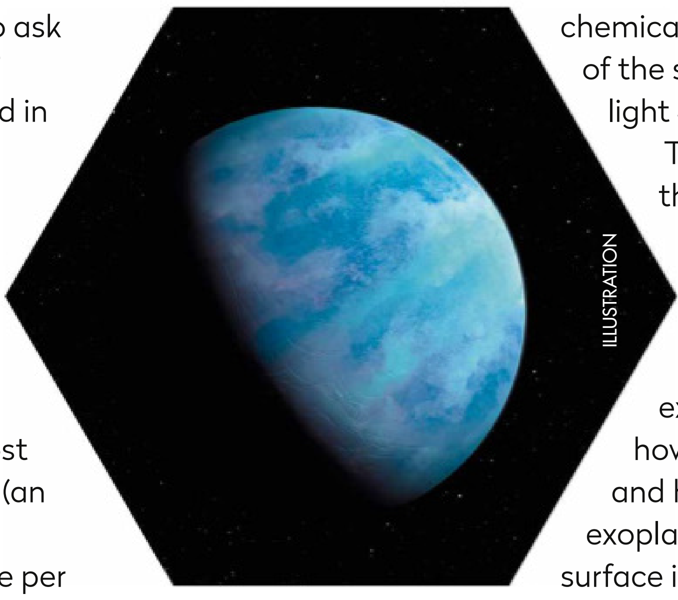
Is there another Earth out there?

JWST's delve into exoplanet atmospheres will tell us just how common Earth-like planets are

Perhaps the biggest question it's possible to ask about the Universe is: 'Are we alone?'. JWST should allow us to make a giant leap forward in finding the answer.

So far we've confirmed over 5,000 exoplanets – planets in other solar systems. The bulk have been found using a technique called the transit method. Although distant planets are too small and dim to be seen directly, we do see a temporary drop in the brightness of their host stars when a planet passes in front of them (an event called a transit).

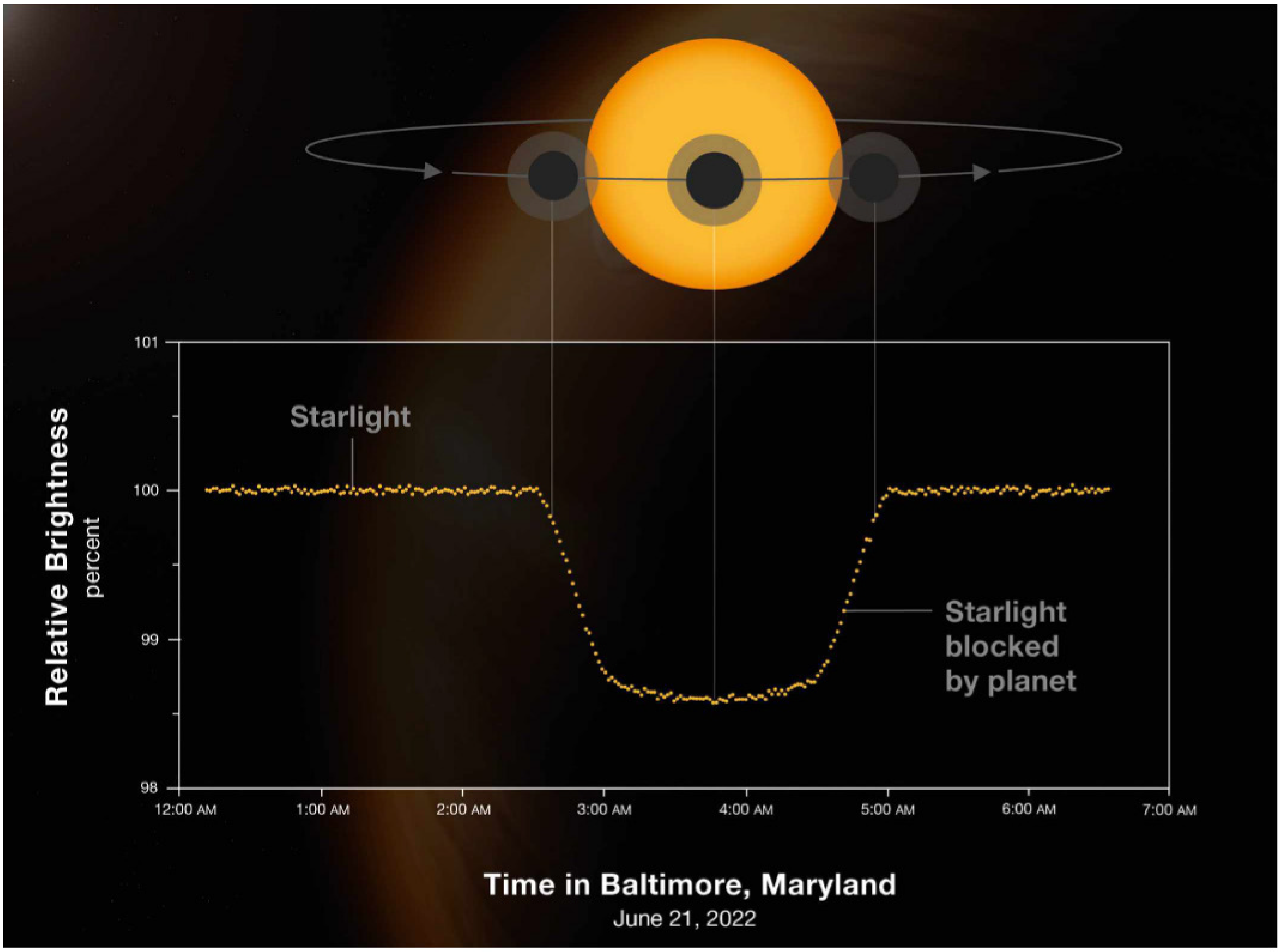
It's a change in brightness of less than one per cent, but it holds a wealth of information. As the planet passes between us and the star, some of the star's light filters through the planet's atmosphere before continuing on towards Earth. Different chemical elements and molecules swallow some of the starlight, leaving distinctive gaps in the light JWST gathers up.



▲ **Gas giant WASP-96b, where clear signs of water were confirmed**

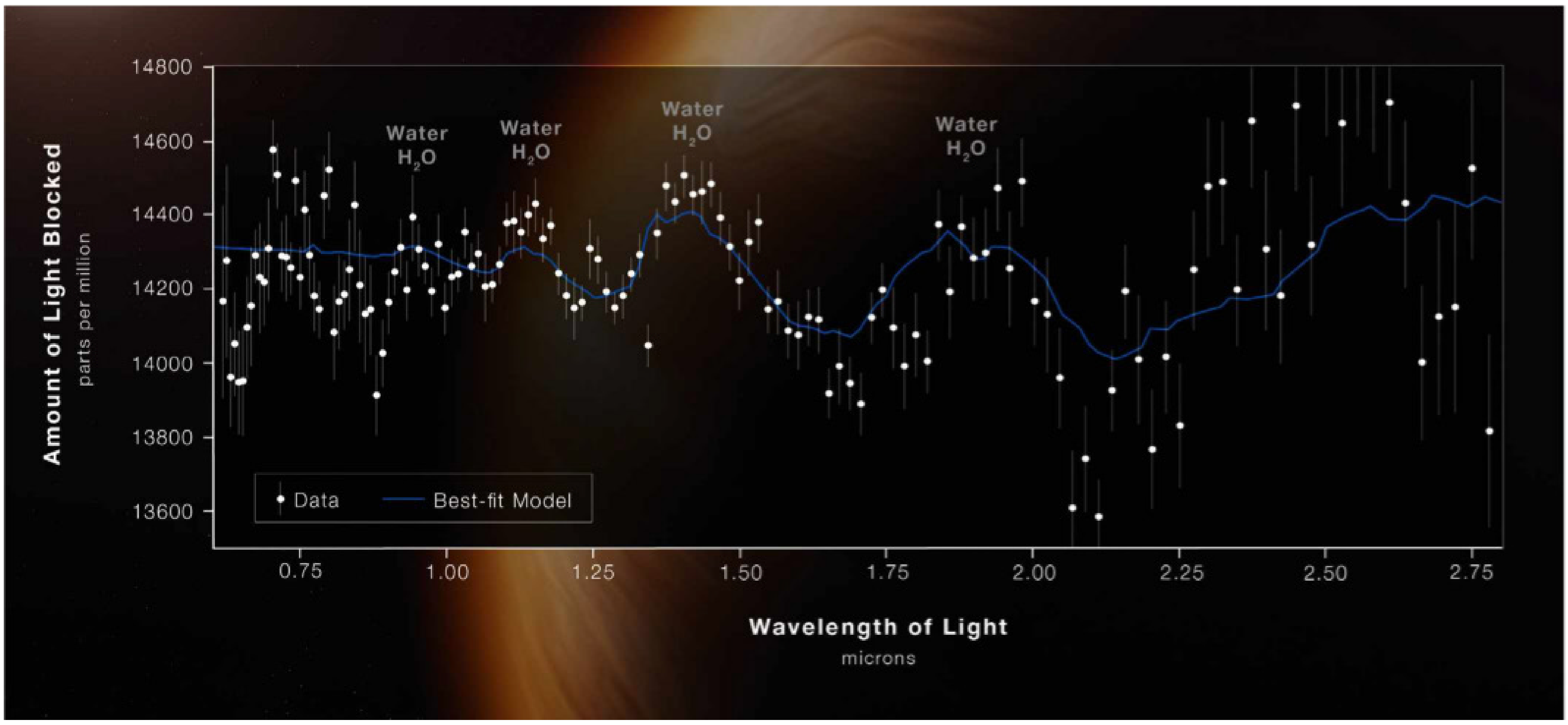
There are some elements and molecules that swallow infrared light, so the gaps that result can't be seen by telescopes that only pick up visible light. Water and methane – which is produced by microbes on Earth – are two key examples. Astronomers want to know how common they are among exoplanets and how abundant they are on individual exoplanets. After all, the majority of Earth's surface is covered in water.

The first data release from JWST contained the transit of an exoplanet called WASP-96b, showing clear signs of water blocking the light from the star. Though this specific planet was known to have water



▲ **The light curve of exoplanet WASP-96b: with its Near-Infrared Imager and Slitless Spectrograph (NIRISS), JWST took 280 individual measurements of minute brightness changes to establish the planet's transit time (2.5 hours), diameter and orbital properties**

NAZARII NESHCHERENSKYI/ISTOCK/GETTY IMAGES, NASA/ESA/CSA/STSCI X 2, BURADAKII/ISTOCK/GETTY IMAGES



▲ Markers for water among the 141-point breakdown of WASP-96b's atmosphere

already, JWST peered into the atmosphere of this alien world in more detail than ever before.

Despite not having been designed to examine exoplanets, it's extremely suited to the task. Previous exoplanetary telescopes had big gaps in their data, as their orbits dip in and out of Earth's shadow. JWST, 1.5 million kilometres from home, has no such problem.

The sheer size of its primary mirror means it can measure the atmospheres of smaller planets than previously possible, including potentially habitable worlds in the TRAPPIST-1 planetary system.

Here, as in all of JWST's science aims – to see the first stars, how worlds are formed, how galaxies evolve – the most exciting observations are yet to come.

Interview: Hannah Wakeford

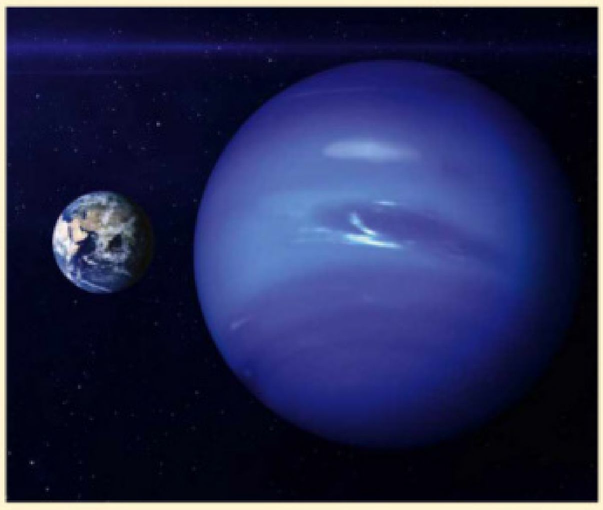
One of the astronomers studying JWST's exoplanet data tells us about the many new worlds the telescope will be exploring

"Most of these planets – including WASP-96b – aren't going to be tourist destinations. They are gas giants about 20 times closer to their stars than we are to the Sun, bombarded by radiation, with winds blowing at thousands of miles per hour. But JWST is going to give us the ability to look at smaller worlds.

Over 50 per cent of planets discovered by the Kepler Space Telescope were somewhere in between the radius of Earth and Neptune (about four Earth radii). We have nothing like that in our Solar System. JWST will look at their atmospheres to find out if they have hydrogen and helium, like Neptune, or if they are giant rocks with little atmosphere at all.

We will also be looking at worlds in the 'Goldilocks' zone, where the temperature allows liquid water on the surface. We have no idea if these small rocky worlds have an atmosphere, so that's the first question JWST is going to be able to answer.

One of the key things, though, with any new telescope is to wait for the unexpected. We will be surprised. The



▲ Many of the planets discovered by Kepler were between Earth and Neptune in size

anticipation for this telescope has been decades in the making. There's an exciting and terrifying amount of data to get through, but we're really excited to be able to share it with everybody."

Hannah Wakeford is an exoplanet scientist and lecturer at Bristol University

ADVERTORIAL

Discover the beautiful night sky in the South of Scotland

The South of Scotland is the perfect choice for a stargazing break away. It's the best of both worlds: an area with one of the lowest levels of light pollution anywhere in the UK, yet close enough to be easily accessible and perfect for a short weekend stargazing break.

But you'll want to stay longer once you discover the peace and beauty of South Scotland's pristine night skies, and the many other attractions besides. Chief among these is Galloway Forest Park – which became the UK's first Dark Sky Park in 2009. Here in this 775km² haven of rolling glens and hills the sky is up to 38 times darker than urban areas, revealing a stunning display of more than 7,000 stars and planets to the naked eye – including the exhilarating sight of the Milky Way's bright silvery band arcing overhead from horizon to horizon.

OTHER UNMISSABLE HIGHLIGHTS INCLUDE

- Experience dark skies with the experts at Moffat Observatory or Galloway Astronomy Centre, Whithorn, and personalised tours with Dark Sky Rangers.
- Immerse yourself in the secrets of the night sky with the interactive exhibits and shows at the Dark Space Planetarium, Kirkcudbright.
- Enjoy a taste of dark skies with Dark Sky Spirits in Moffat, a Dark Sky Community, or on a tour of the Dark Art Distillery in Kirkcudbright.
- Relax in a hot tub beneath the starry skies at Loch Ken Eco Bothies beside Galloway Forest Dark Sky Park, or Singdean Chalet in the secluded hills of the Scottish Borders.

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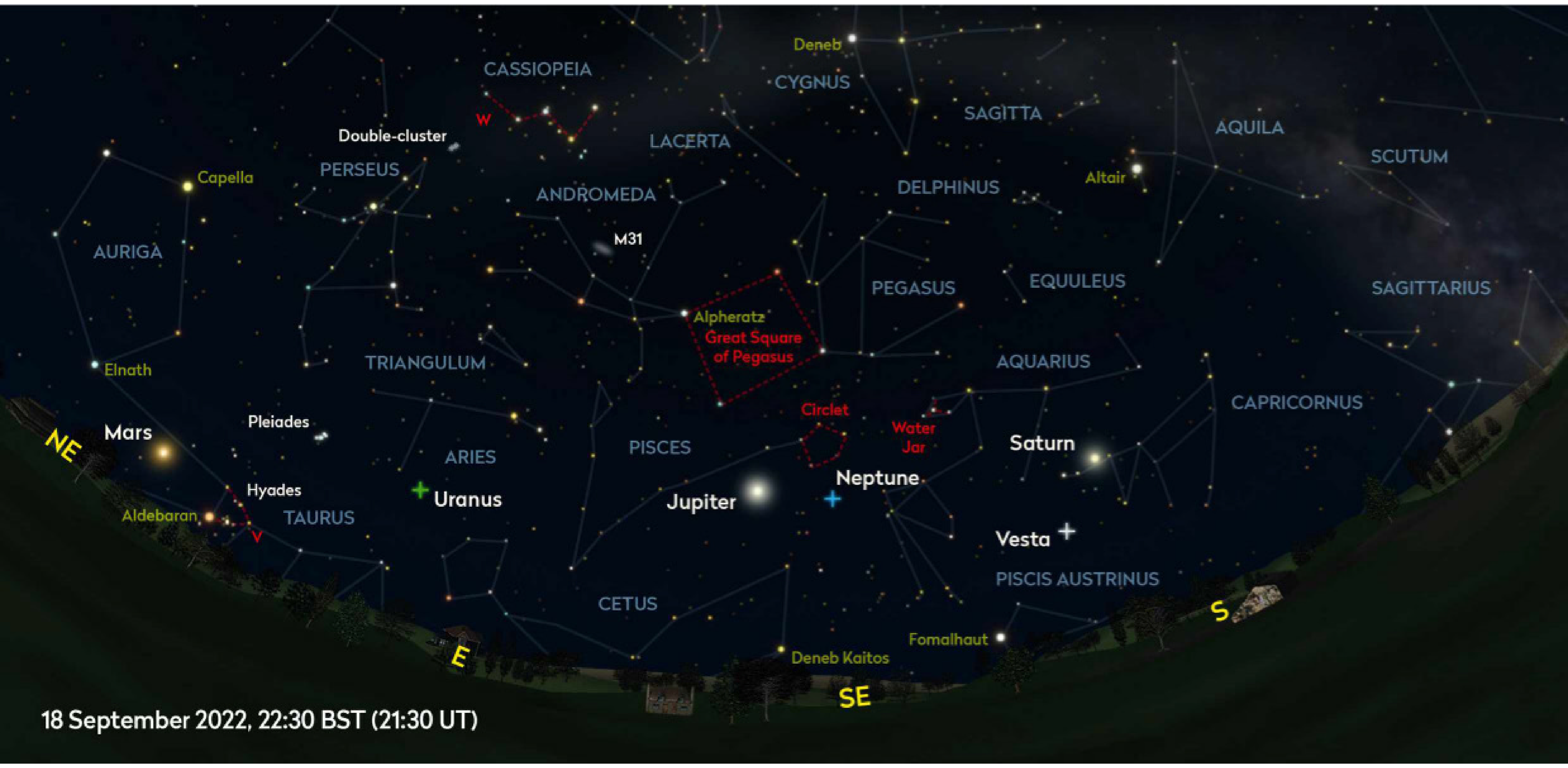
String of jewels: Mars, Jupiter and Saturn will all be visible with the naked eye in September's night sky

Prepare for the PLANET PARADE

Five planets and an asteroid will be putting on a show this month. **Stuart Atkinson** shows us where and when to catch the spectacle

ARUIZHU/ISTOCK/GETTY IMAGES



▲ **Cast your eyes southeast to catch the rare sight of (left to right) Mars, Jupiter and Saturn strung across the sky and all very easy to see**

While it's been disappointingly quiet for comet observers, aurora hunters and meteor watchers, there's no doubt that 2022 has been a great year for planet spotters. Back in early summer there was a striking and much-hyped 'chain of worlds' spread out across the sky, with half a dozen planets strung out along the ecliptic like beads on a bracelet. Unfortunately, that celestial treat was only visible before dawn, so many people missed it or didn't even know it was happening at all.

But good news: another planetary parade will be on view this month! And even better news: this time it will be in the evening sky, so you won't need to set the alarm really early to see it. Throughout September no less than five planets – Saturn, Jupiter, Mars, Uranus and Neptune – will all be on view at once, if you look at the right time.

As exciting and rare as it was, summer's planetary line-up wasn't easy to see for many Northern Hemisphere sky-watchers – some of the planets were overwhelmed by the bright summer sky. But this month's gathering will be taking place after dark, so all the planets involved will be either very easy to see with the naked eye or easy to find in binoculars and small telescopes. And as an added bonus, one of the Solar System's most famous minor planets, Vesta, will be in the same region of the sky too.

But when will be the 'right time'? Although some of these worlds will be on view soon after sunset, you won't be able to see all of them strewn across the sky together until around 10:30pm, so if you want to show them to any space-mad youngsters, they may need to take a nap first and then go out later. We'll look at the view on one particular night mid-month, 18 September, but don't worry if it's cloudy on that night because these planets will be on view throughout September.

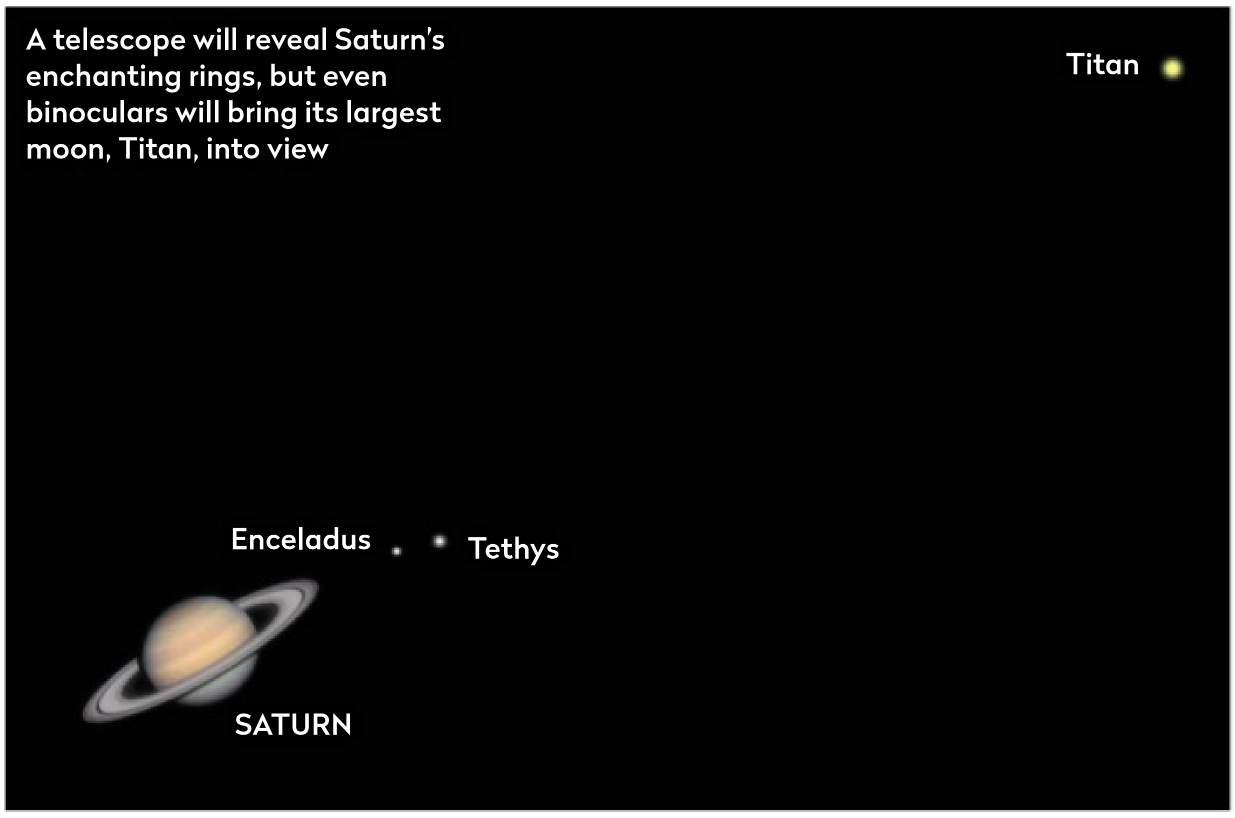
"With the naked eye, September's planet parade will be a celestial joy to behold"

By 10:30pm, if you look to the southeast, a veritable parade of worlds will be stretched out before you. The brightest of them, Jupiter, will be straight ahead of you. To its right, 45° away, Saturn will be an easy naked-eye object too, also appearing starlike. Finally for the naked-eye planets, down to Jupiter's lower left, quite some distance away (70° away in fact), you'll see Mars.

With the naked eye, September's planet parade will be a celestial joy to behold, but to get a closer look at those brighter planets, a small telescope or even a modest pair of binoculars will make all the difference. Let's take a closer look at each of the naked-eye trio in turn, working from right to left, then explore how to see Uranus, Neptune and Vesta. As always, it will help if you can get to somewhere dark, away from the bright lights of towns and cities, and allow 20–30 minutes for your eyes to dark-adapt. So wrap up warm, have hot drinks and snacks to hand, and get ready for the planet parade.

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy and spaceflight

CHART BY PETE LAWRENCE, MICHAEL KARRER/CCDGUIDE.COM X 2



A telescope will reveal Saturn's enchanting rings, but even binoculars will bring its largest moon, Titan, into view

Saturn

Shining at mag. +0.4, the famous ringed planet will rise an hour before sunset, but you won't be able to see it clearly until twilight deepens. By 10:30pm (from the centre of the UK; times will vary depending on your location) Saturn will look like a yellow-white star in Capricornus. If you're worried about how you'll know which one is Saturn, don't be: it will be easy to identify because it will be the only bright 'star' low in the southeast.

Having found Saturn, you'll want to see its famous rings. They're a sight reserved for telescopes or the largest and most powerful binoculars, but even a modest pair of binoculars will show you Saturn's largest moon, Titan, which is as big as the planet Mercury. Through binoculars Titan looks like a star shining close to Saturn. Its position relative to Saturn changes night to night, so check where it will be using a phone app or planetarium program.

Magnified more, Saturn really comes to life. Even a small telescope using low magnification is enough to show its slightly squashed disc and its rings too, looking like a slender hoop thrown over it. As magical as this view is – and every astronomer can't help grinning like a Cheshire Cat whenever they recall their first view of Saturn through a telescope – you won't be surprised to hear that the bigger the telescope you use, the better your view of Saturn will be. A 6-inch reflector with high magnification will show you faint banding on the planet's disc, gaps in the rings and even the shadow of the rings on Saturn itself – a view as beautiful as anything sent back by Voyager or Cassini.

Pan over to find bright Jupiter, where all you need are binoculars to make out its four Galilean moons

Jupiter

Sitting smack in the middle of the chain of worlds at 10:30pm, Jupiter will look like a strikingly bright blue-white star to the eye, 30° or so above the southeastern horizon. You'll have no trouble identifying it because, at mag. –2.9, there will simply be nothing else anywhere near as bright in the sky nearby at that time.

Through a pair of binoculars Jupiter will just look like a brighter star, but you will be able to see some of its family of 79 moons, looking like tiny stars shining close to it. How many you see will depend on when you look. The four largest moons of Jupiter are known as the Galilean satellites because they were first seen by the great astronomer Galileo when he turned his crude telescope on the night sky. But as Galileo found, as they whirl around Jupiter they slip in and out of view, sliding in front of the disc or vanishing behind it, so you might see all four or just a couple. The Jupiter's Moons diagram in 'The Sky Guide' on page 49 will tell you how many moons you will be able to see, and which ones they are, across September.

Through a telescope Jupiter is a wonder. Even a small instrument will show two dark horizontal bands on its shimmering disc, and those Galilean moons will look more obvious too. A large telescope magnifying at 100x will bring subtler cloud bands into view, and Jupiter's famous Great Red Spot – a storm larger than Earth – will be visible too. If you can magnify a couple of hundred times, you'll see plumes and swirls of pastel-hued clouds on its disc, and more of its moons will be visible. ▸

It may lack Jupiter and Saturn's size, but Mars's salmon surface and dark markings are no less impressive through the eyepiece

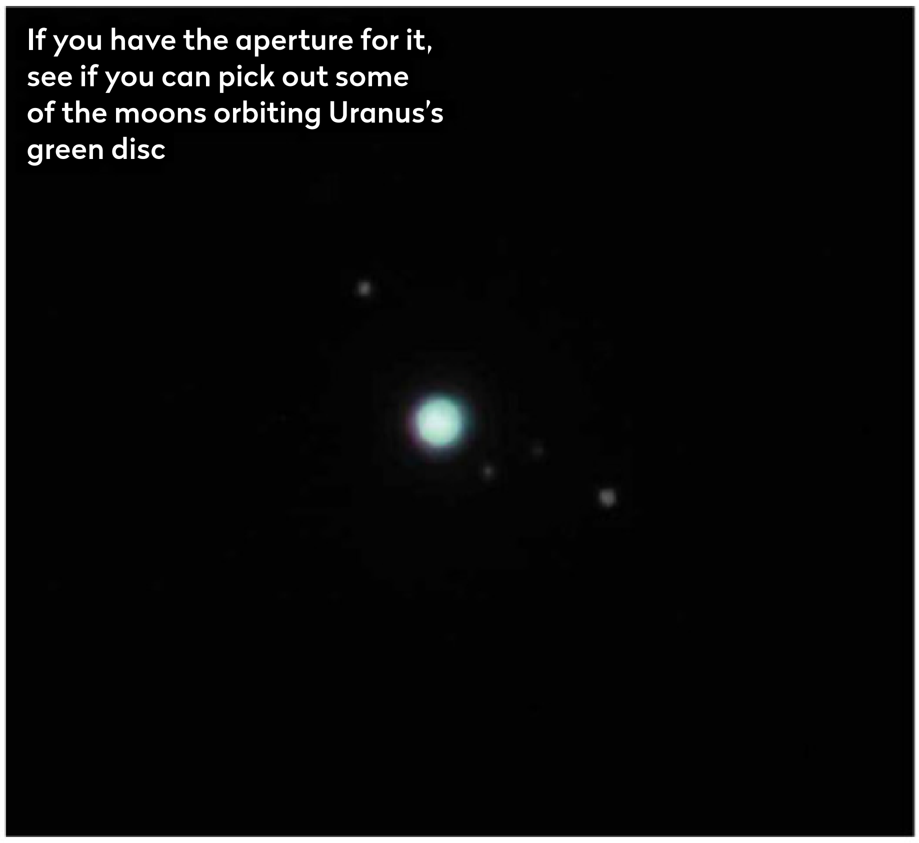
Mars

The anchor at the far western end of our celestial chain of worlds is Mars. Like Saturn and Jupiter to its right, to the naked eye Mars will look like a 'star' in Taurus. Shining at mag. –0.4 it will be obvious, but if you go out expecting the famously 'red' planet to blaze a vivid scarlet, you're going to be disappointed. Mars is actually more of a deep orange colour, like amber or one of the old Spangles boiled sweets.

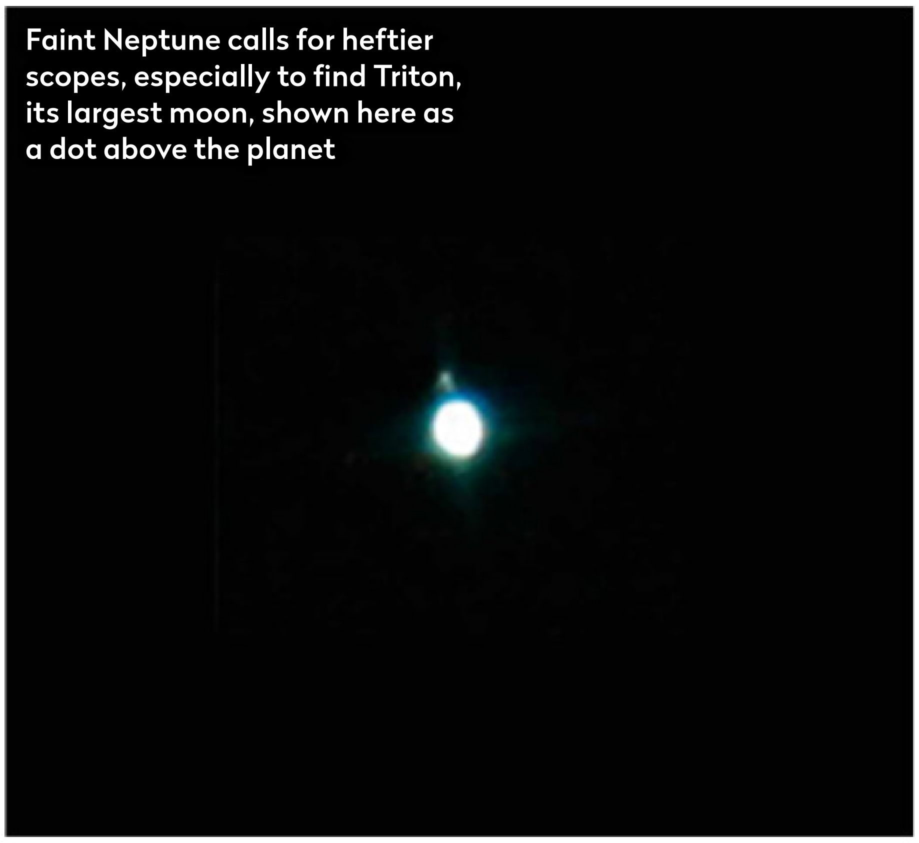
If you have a pair of binoculars, they are definitely worth training on Mars. They won't be powerful enough to show you its disc, but they will greatly enhance its colour, making the planet appear like a gemstone in the sky.

Everyone is familiar with images of Mars taken from orbit, showing its ochre disc blotted with dark areas, but if you want to see that for yourself you'll need a large scope, like a 6-inch+ refractor, high powers and good seeing. During September, Mars's disc will only appear half as wide as Saturn and a sixth as wide as Jupiter, but you might just sneak a tantalising glimpse of its ice cap through a smaller instrument in moments when the atmosphere between you and Mars is calm and still.

Now we've looked at the three naked-eye worlds, let's go fainter...



If you have the aperture for it, see if you can pick out some of the moons orbiting Uranus's green disc



Faint Neptune calls for heftier scopes, especially to find Triton, its largest moon, shown here as a dot above the planet

Uranus

During mid-September you'll find Uranus roughly halfway between Mars and Jupiter. With a magnitude of +5.9 the planet will technically be a naked-eye planet, but unless you know exactly which of the hundreds of 6th-magnitude points of light in that part of the sky it is, you'll struggle to pick it out. Binoculars will show Uranus as a star with a subtle greenish hue, and if you have a telescope it will resolve the planet's small, pale green disc, confirming its identity. Again, a good stargazing app or planetarium software will help you pinpoint the planet.

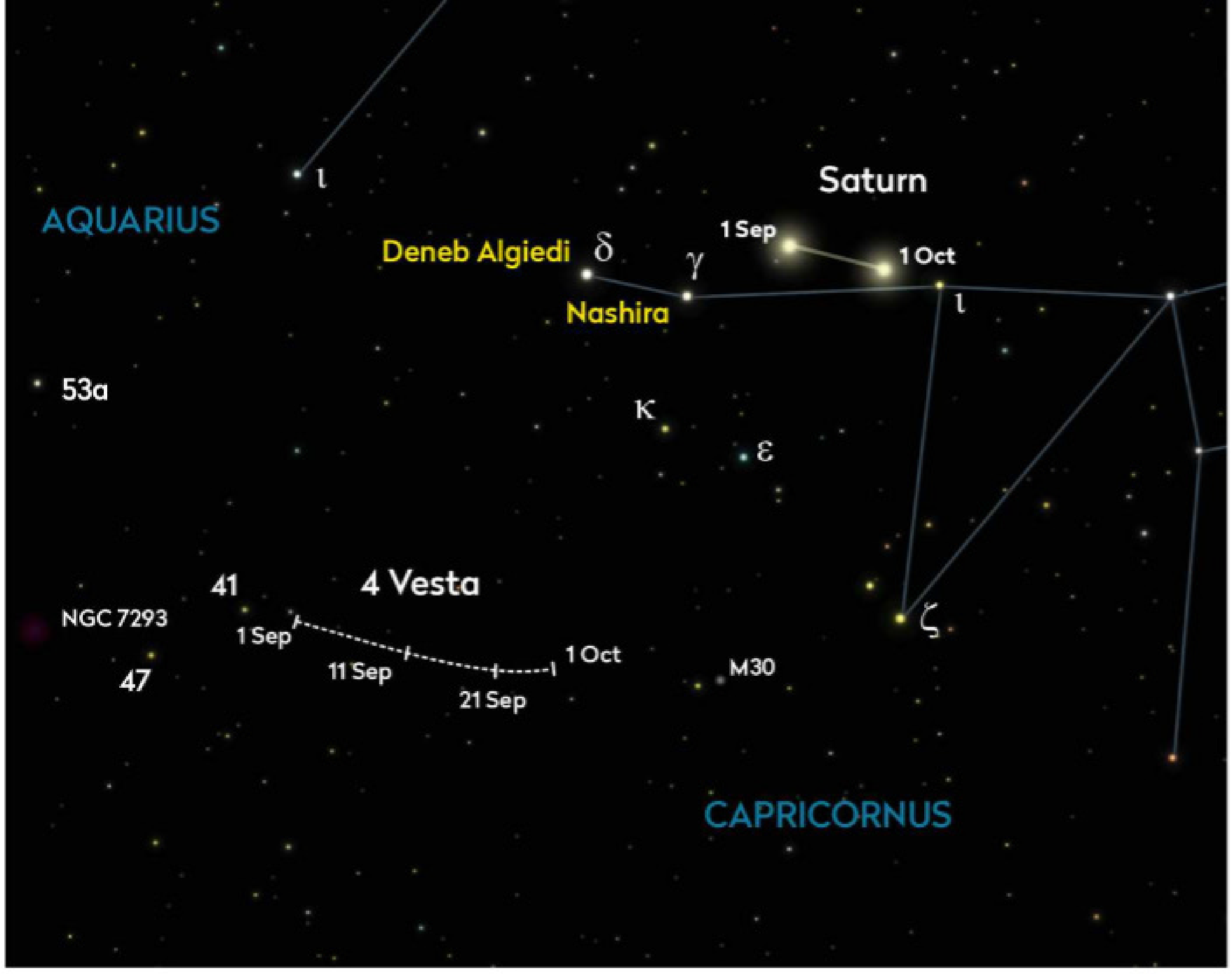
Neptune

If you've never managed to see Neptune with your own eyes before, this will be your big chance. During September it will be just 11° away from Jupiter. However, with a magnitude of just +7.8, it is far too faint to see without assistance. Binoculars will only show it as a faint blue-green 'star' lost among thousands of others of equal or even greater brightness within Aquarius. If you want to be certain of seeing it, you'll need a telescope like a 6-inch or larger refractor, which will show you the faraway planet's tiny blue-green disc at high magnification.

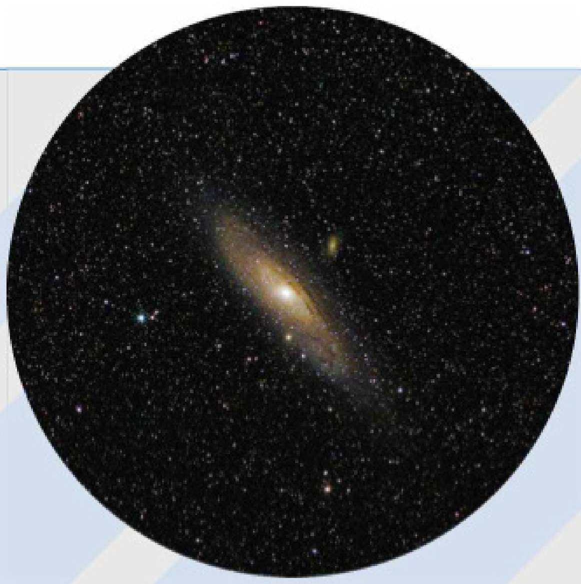
Vesta

With a diameter of around 525km, Vesta is one of the largest known asteroids. Discovered in March 1807 by the German astronomer Heinrich Wilhelm Matthias Olbers, it was named after Vesta, the virgin goddess of home and hearth from Roman mythology.

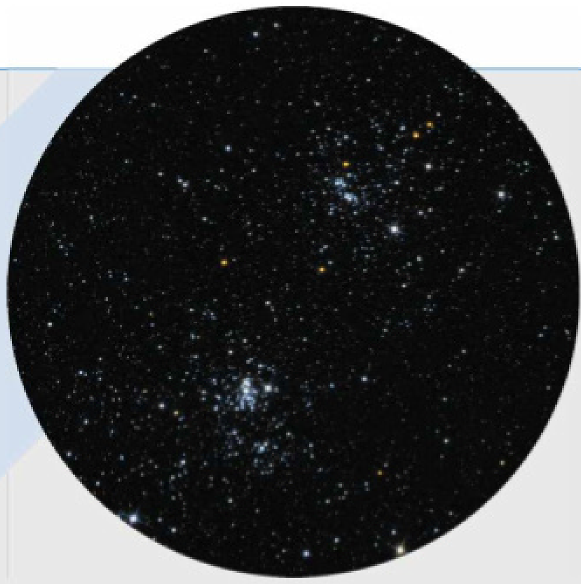
Vesta is the brightest asteroid visible from Earth, regularly visible to the naked eye as a 5th-magnitude star. This month it be will a magnitude-and-a-half fainter than that, so you'll need a pair of binoculars to see it, and no matter how big a telescope you point at it, it will still just look like a point of light. Its brightness or appearance won't change much during the whole of September, so you can seek it out at any time. In fact, it might make a fun challenge to take several photos of its part of the sky, a week or so apart, and look to identify which 'dot' to the lower left of Saturn has moved during the month.



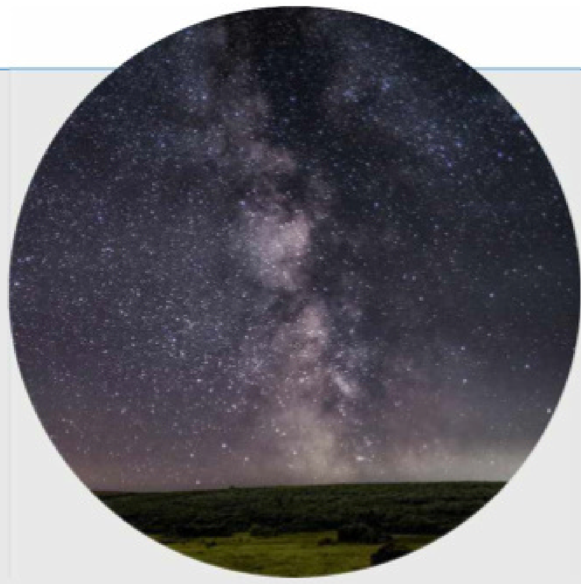
▲ You can track the motion of 4 Vesta, brightest of the asteroids, as it passes below Saturn



▲ Best seen with a medium-sized telescope, the Andromeda Galaxy is easy to find and never disappoints



▲ Stunning in binoculars or a small scope, the Double Cluster near the famous 'W' of Cassiopeia is well worth seeking out



▲ The star-spangled core of the Milky Way, seen here from Devon in September 2021, can be a real treat in dark skies

More to explore

Once you've taken in the planet parade, there's a wealth of other celestial delights to see in the night sky this month

When you've identified all the planets and explored them with your binoculars or telescope, take a while to look at some of the other objects on view in the September sky. Mars will lie close to two famous star clusters. To its right you'll see what looks like a 'V' of stars lying on its side. This is the Hyades star cluster, which represents the horns of Taurus, the Bull. The bright orange star at the end of the lower horn is the red giant Aldebaran, but it's not actually a member of the cluster, it just lies in the same direction. Above the Hyades you'll see a small knot of blue stars, around the same size as your thumbnail held out at arm's length: the famous Pleiades or Seven Sisters open star cluster. Binoculars will show there are a lot more than just seven stars in this group, which is shaped a little like a mini Big Dipper. Other objects worth tracking down after you've toured the planets are:

M31, the Andromeda Galaxy
Over two million lightyears away, this is the most distant object the naked eye can see.

The Double Cluster
These glittering star clusters sit so close together they fit in the same binocular and small telescope field of view.

The Milky Way
The dark evenings of September are perfect for getting away from light pollution and enjoying the beautiful sight of the star-frothed Milky Way airbrushed across the sky, with the most concentrated area to be found above the southwest horizon.

The periodic table of Messier objects

Observing deep-sky objects just got a little bit easier thanks to **Tom Urbain's** at-a-glance guide to the targets of the Messier Catalogue

Charles Messier began his catalogue of observing targets in the mid-18th century to list items that would distract him and his assistant, Pierre Méchain, from their real aim of discovering comets. In the centuries since, the targets listed in the Messier Catalogue have undoubtedly become the most observed deep-sky objects in the night sky by amateur astronomers and astrophotographers.

KEY

Viewing season →
Messier object number →
Apparent magnitude →

GALAXIES - 40
NEBULAE - 10
OPEN CLUSTERS - 28
GLOBULAR CLUSTERS - 28
UNIQUE OBJECTS THAT DON'T FIT THE ABOVE MAIN CATEGORIES - 4

BRIGHTER ↓ DIMMER

VERY EASY	EASY				
	SUMMER M7 3.0	WINTER M44 3.1	AUTUMN M31 3.4	SUMMER M6 4.0	WINTER M47 4.4
WINTER M45 1.2	SUMMER M23 5.5	AUTUMN M34 5.2	AUTUMN M39 4.6	SUMMER M25 4.6	WINTER M41 4.5
WINTER M42 4.0	WINTER M37 5.6	WINTER M48 5.8	WINTER M50 5.9	WINTER M36 6.0	SUMMER M16 6.0
WINTER M35 5.1	SPRING M3 6.2	WINTER M93 6.2	WINTER M46 6.1	WINTER M67 6.1	SUMMER M17 6.0
SUMMER M22 5.1	AUTUMN M15 6.2	SUMMER M92 6.4	WINTER M38 6.4	AUTUMN M2 6.5	SUMMER M28 6.8
SUMMER M5 5.7	SUMMER M80 7.3	AUTUMN M30 7.2	SUMMER M29 7.0	SPRING M81 6.9	AUTUMN M52 6.9
SUMMER M13 5.8	SUMMER M27 7.3	AUTUMN M103 7.4	SPRING M53 7.6	SPRING M104 8.0	AUTUMN M32 8.1
SUMMER M11 5.8	SPRING M40 9.1	WINTER M43 9.0	SPRING M66 8.9	SUMMER M57 8.8	SPRING M82 8.4

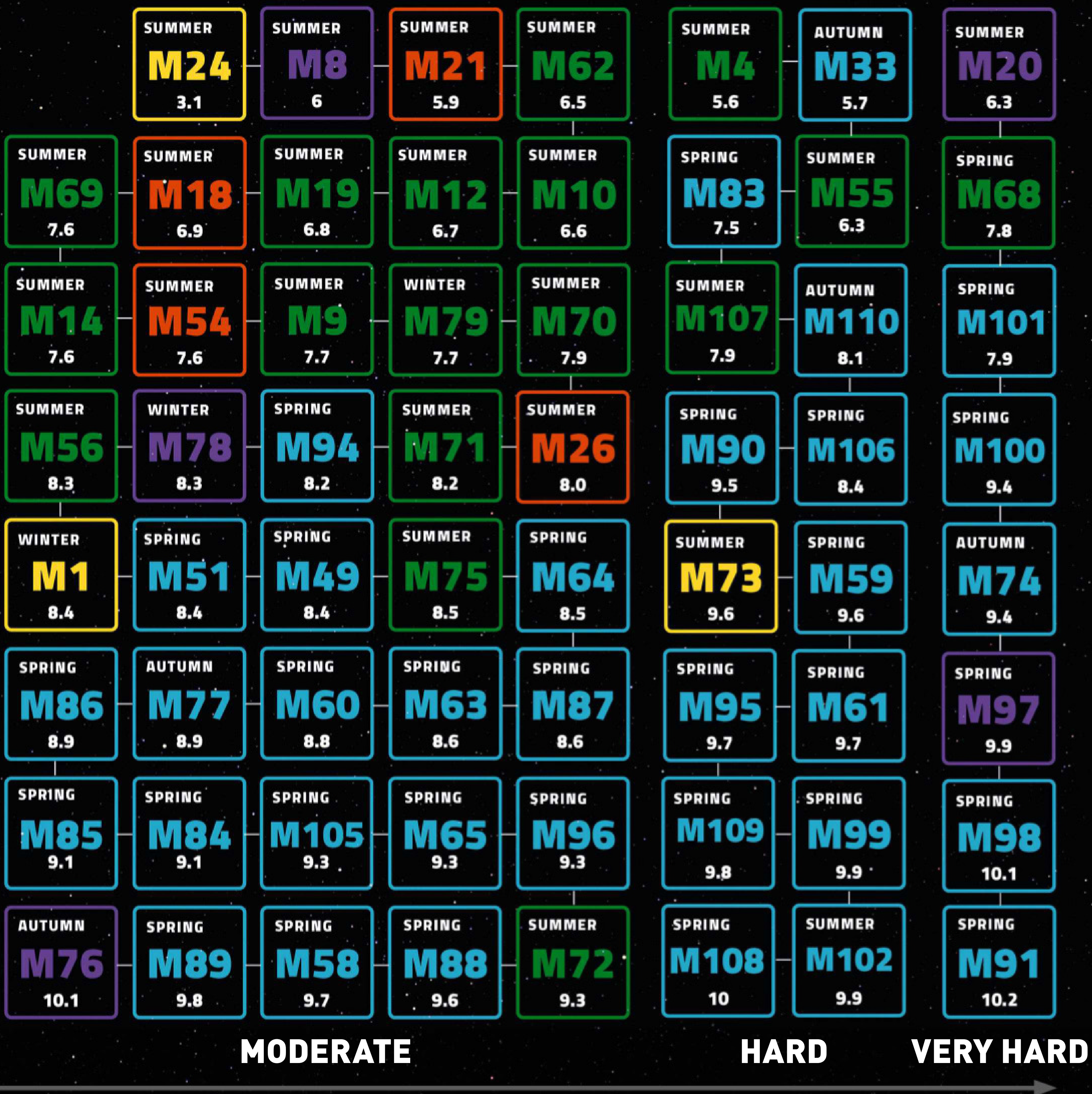
TOM URBAIN, GRAPHIC CREATOR: STARLUST.ORG, DATA SOURCE: TONY FLANDERS

First published in 1781 containing 103 objects, historical research in the 20th century identified a further seven objects that were observed by the French astronomers, bringing the catalogue up to today's total of 110 targets. To present this quantity of intriguing astronomical objects in a more understandable way, amateur astronomer Tom Urbain has transformed the list into a periodic table.

"There are quite a lot of Messier objects, so I created the infographic to visually organise them into five different groups according to viewing difficulty, from very easy to very hard," says the UK-based astro-imager. "I based this on using a mid-range telescope, such as a refractor of 8-inch aperture."

"Each cell contains the Messier object's number, the best viewing season and the apparent magnitude," he continues. "The cells are also colour-coded depending on the object type, so it's easy to see which is a galaxy, a nebula, an open cluster or a globular cluster. Within each difficulty group, the objects are also organised from brightest at the top to dimmest at the bottom."

The graphic offers structure to the challenge of finding and observing the Messier objects. "It makes the 'trial and error' phase that we all go through a little easier when starting out," says Tom. "Beginners can therefore refrain from trying to observe very faint Messier objects with a 4- or 6-inch telescope and wondering what went wrong when they can't see anything."



16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

SEPTEMBER 2022

HIDDEN BY THE MOON

Watch Uranus disappear from view in a lunar occultation on 14 September

SHIFTING SHADOWS

Track the changes in Gallilean moon shadows as Jupiter reaches opposition

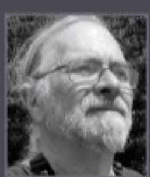
WAFER-THIN MOON

Keep your eyes out for a slender morning Moon near Venus

JUHKU/ISTOCK/GETTY IMAGES

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Magnificent Jupiter reaches opposition
- ✦ Spot what's odd about a Harvest Moon
- ✦ Minor planet 3 Juno at opposition

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

SEPTEMBER HIGHLIGHTS

Your guide to the night sky this month

Thursday 1

The Moon is out of the way at the start and end of September, making these perfect times to take this month's Deep-Sky Tour (see page 56).

Saturday 3 ▶

Catch the first quarter Moon 2.3° from the mag. +1.0 red supergiant Antares (Alpha (α) Scorpii) as the sky begins to darken.

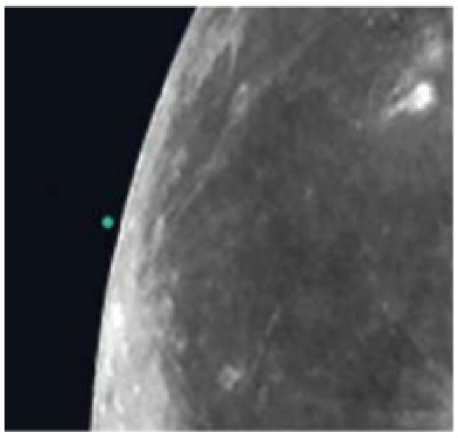
Wednesday 7

Mag. –0.2 Mars lies 4.3° from mag. +0.8 Aldebaran (Alpha (α) Tauri) in this morning's sky. Both objects will be showing a distinctive orange hue.

Thursday 8

This evening's 96%-lit waxing gibbous Moon lies 7° from mag. +0.5 Saturn.

Minor planet 3 Juno reaches opposition, shining at mag. +7.8 in the constellation Aquarius, 10° west of similarly bright Neptune.

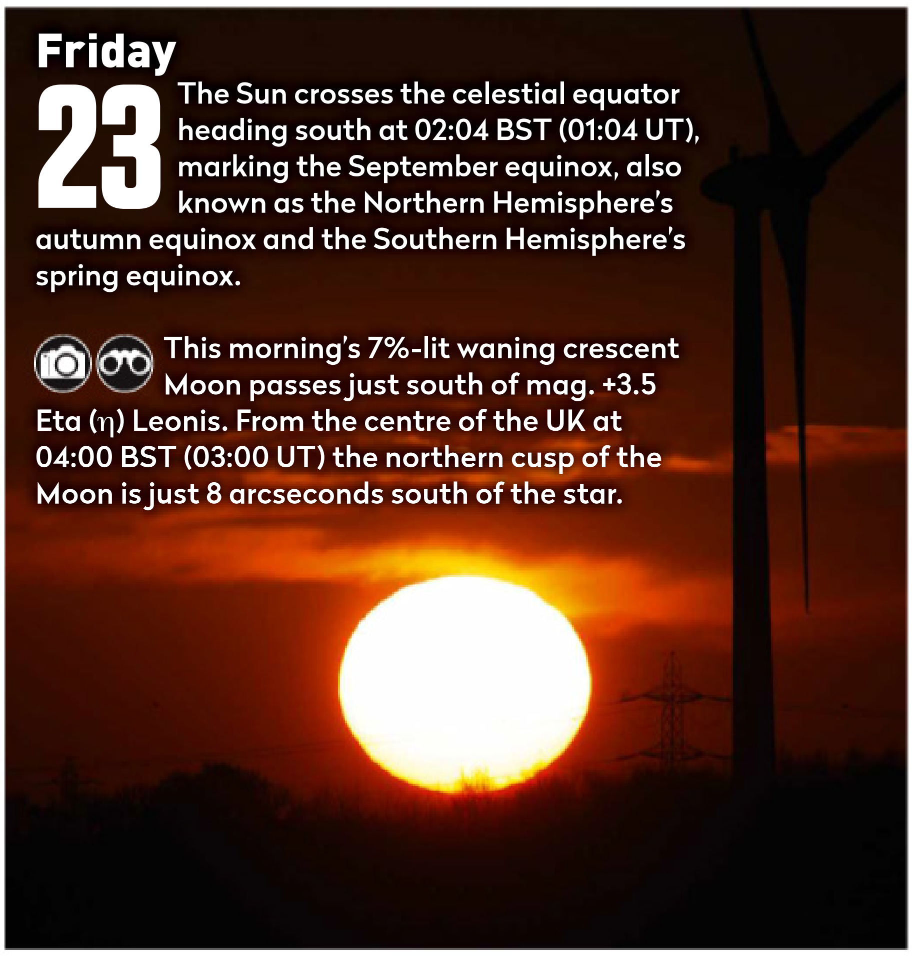


◀ Wednesday 14

This evening's 77%-lit waning gibbous Moon will occult the planet Uranus. It disappears at 22:30 BST (21:30 UT), reappearing at 23:21 BST (22:21 UT). Times will vary slightly with location. Turn to page 46 for more.

◀ Friday 16

Neptune reaches opposition in Aquarius. Currently located around 6° south of the Circlet asterism in Pisces, the planet shines at mag. +7.8.



Friday 23

The Sun crosses the celestial equator heading south at 02:04 BST (01:04 UT), marking the September equinox, also known as the Northern Hemisphere's autumn equinox and the Southern Hemisphere's spring equinox.

This morning's 7%-lit waning crescent Moon passes just south of mag. +3.5 Eta (η) Leonis. From the centre of the UK at 04:00 BST (03:00 UT) the northern cusp of the Moon is just 8 arcseconds south of the star.

Saturday 24

Io and its shadow transit Jupiter this morning from 02:57 BST (01:57 UT) until 05:12 BST (04:12 UT). As the planet is near opposition, the moon and its shadow will appear very close together.

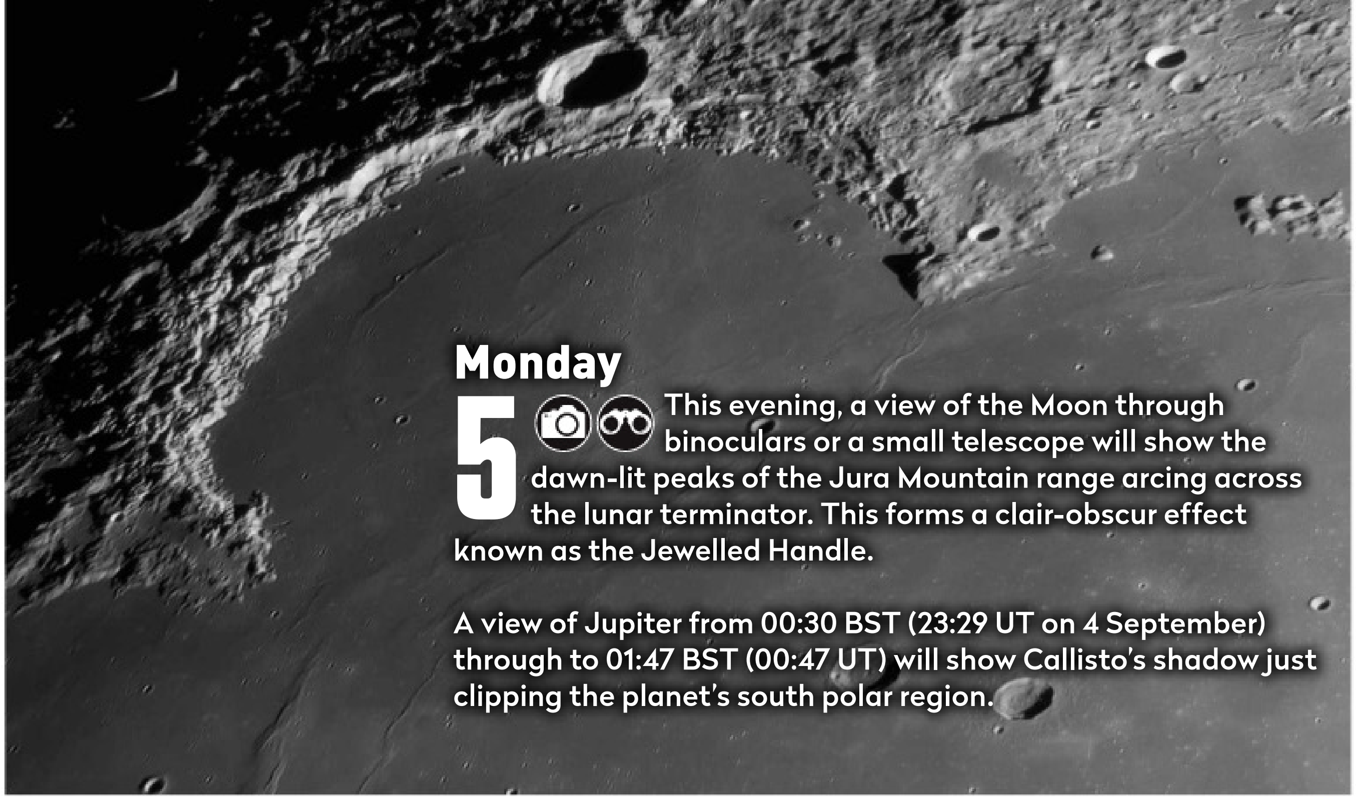
Sunday 25

From 06:30 BST (05:30 UT) there's an excellent chance to spot an ultra-thin 0.6%-lit waning crescent Moon just 2° north of mag. –3.8 Venus. Turn to page 47 for more.

Wednesday 28 ▶

The giant moon Ganymede, along with its shadow, transit Jupiter from 05:06 BST (04:06 UT), the event still in progress as Jupiter sets.

PETE LAWRENCE X 9



Monday

5 This evening, a view of the Moon through binoculars or a small telescope will show the dawn-lit peaks of the Jura Mountain range arcing across the lunar terminator. This forms a clair-obscur effect known as the Jewelled Handle.

A view of Jupiter from 00:30 BST (23:29 UT on 4 September) through to 01:47 BST (00:47 UT) will show Callisto's shadow just clipping the planet's south polar region.

Saturday ▶

10 The Moon is full at 10:59 BST (09:59 UT) but won't be visible until later in the day. This full Moon is closest to the September equinox, making it the Harvest Moon for 2022.

Sunday

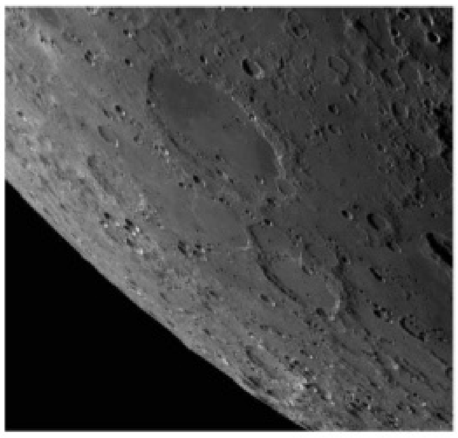
11 Just after rising this evening, the 97%-lit waning gibbous Moon lies 3.8° to the east of mag. –2.8 Jupiter.

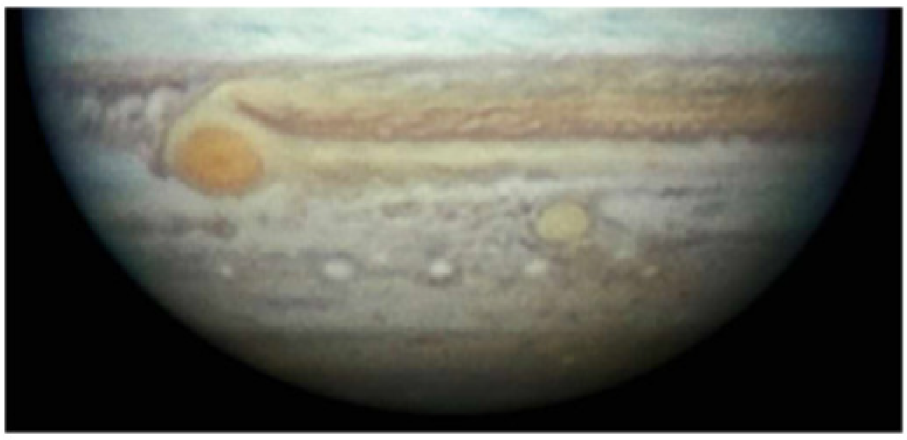
Saturday

17 The 58%-lit waning gibbous Moon sits 2.9° north of mag. –0.4 Mars this morning. Catch them together after 01:00 BST (00:00 UT).

Thursday ▶

22 This morning is the second of two opportunities to catch our Moonwatch target, the walled plain Schickard. The first is on the evening of 8 September. See page 52.





◀ Monday

26 The planet Jupiter reaches opposition today, shining at mag. –2.8 in Pisces.

Catch an ultra-thin waxing crescent Moon shortly after sunset. Turn to page 47.

Friday

30 The 25%-lit waning crescent Moon this evening sits 2.3° from mag. +1.0 Antares (Alpha (α) Scorpii), the pair visible low above the southwest horizon shortly after the Sun has set.

Family stargazing

The full Moon on 10 September is the Harvest Moon for 2022, so-called because the difference in rise times from one evening to the next after this date is the smallest for the year. This means the bright, fuller phases of the Moon appear at approximately similar times, lighting the way to collect the harvest. Young scientists might like to make a note of the rise times for the Moon from 10 September onwards (find them at **www.timeanddate.com/moon**) and calculate the difference. Try to remember to do this next March too, when the difference is greatest. **bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

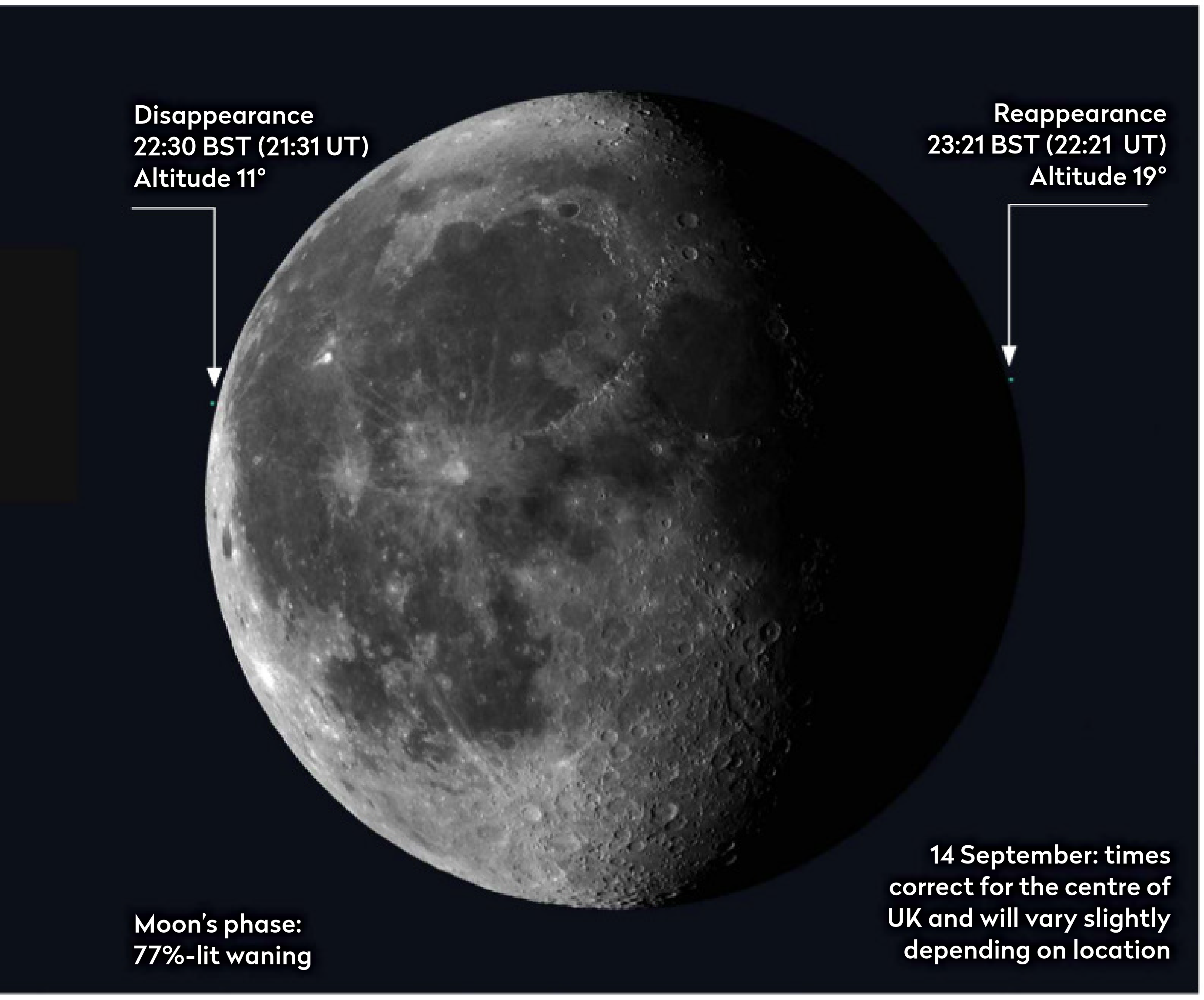
If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE The top sights to observe or image this month

DON'T MISS

Lunar occultation of Uranus

BEST TIME TO SEE: 14 September, 21:30 BST (20:30 UT) until 23:30 BST (22:30 UT)



▲ It will take around eight seconds for Uranus to disappear behind the Moon's leading, bright limb as occultation begins

▲ After disappearing for 50 minutes, its return from behind the Moon's following, dark limb will also take eight seconds

The Moon will appear to pass in front of the planet Uranus on 14 September, an event known as a lunar occultation. Lunar occultations of faint stars are common, but seeing the Moon move in front of a bright star is relatively infrequent. Seeing the Moon pass in front of a planet is quite a rare event.

On 14 September, the Moon will be at 77%-lit waning gibbous phase. Uranus, shining at mag. +5.7 will require binoculars or a telescope to see properly. Locate the planet at 21:30 BST (20:30 UT) and familiarise yourself with where Uranus is positioned relative to the Moon's disc. At this time, the separation between Uranus and the eastern edge of the Moon (confusingly, the Moon's western limb) will be around one apparent lunar diameter. There's nothing else of a similar brightness nearby, so identifying Uranus shouldn't be too hard. Once you've located it, there's nothing more to do than wait.

The Moon's bright limb slowly approaches Uranus until first contact, the time of which varies slightly with location. It's recommended to keep watching the planet when the Moon is close. From the centre of the UK, Uranus will make contact with the Moon's eastern edge (western limb) at 22:30 BST (21:30 UT).

Uranus has an apparent diameter of 3.7 arcseconds and will take around eight seconds to fully disappear. Atmospheric seeing will have a big effect here, the tiny planetary disc being heavily influenced by Earth's unstable atmosphere.

Uranus remains hidden for around 50 minutes, the planet reappearing at 23:21 BST (22:21 UT) from behind the Moon's dark western edge (eastern limb). The period of time Uranus is hidden will also vary slightly with location, so observe the Moon's dark edge earlier than the expected reappearance, say from 23:10 BST (22:10 UT). Again, Uranus should take around eight seconds to be fully revealed as the Moon moves east.

A telescope setup showing the entire Moon's disc guarantees a view of the reappearance, although it'll be hard to see Uranus as anything more than a dot. More magnification will show the planet as a disc, but this increases the possibility of missing the reappearance. If you have an accurate, polar-aligned mount, centring on Uranus at high magnification and sticking with it as the Moon performs the occultation is the best way to guarantee a high-powered view.

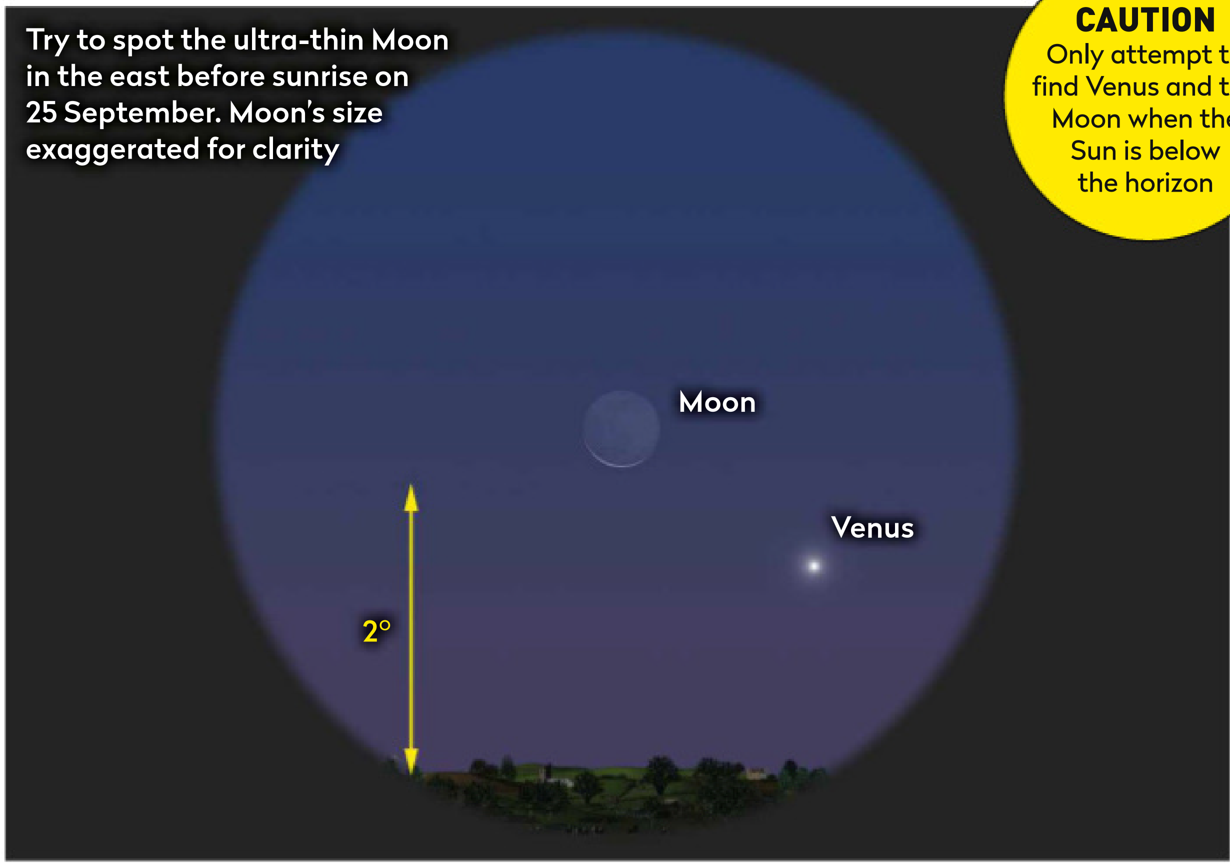
ALL PICTURES: PETE LAWRENCE

Thin Moon spotting with Venus

BEST TIME TO SEE: 25 September, from 40 minutes before sunrise (stop viewing at sunrise)

When the Moon is presented against a truly dark sky, it's easy to locate as it dominates the view. When it's in the daytime sky, it's less easy to see due to lower contrast, but the thicker phases can still stand out pretty well. When the Moon appears in the daytime sky or twilight periods with a phase less than 2% it becomes significantly trickier to pick out. When it's presented with a phase less than 1% it's downright difficult!

This will be the case on the morning of 25 September: a 0.6%-lit waning crescent Moon situated 8˚ from the Sun. This is an interesting arrangement for several reasons. The ecliptic makes a steep angle with the eastern horizon at this time of year before sunrise. This means that the Moon, which never moves that far from the ecliptic, will be optimally placed above the horizon before sunrise. In addition, there's a theoretical limit as to how far a Moon can be from the Sun before it becomes invisible. This value is known as the Danjon limit and is usually quoted as about 7˚. The morning Moon on 25 September is perilously close to this value, with an actual separation value of 7.9˚ from the Sun.



Try to spot the ultra-thin Moon in the east before sunrise on 25 September. Moon's size exaggerated for clarity

CAUTION
Only attempt to find Venus and the Moon when the Sun is below the horizon

But best of all, if you go looking for this particular Moon, you'll have a guide in the form of the brilliant planet Venus. If you have a clear view looking towards the eastern horizon on the morning of 25 September, point your binoculars at Venus and in the same field of view, just to the left and up a bit from the planet, there will be that ultra-thin lunar crescent. If you look but can't see it, look again removing all preconceptions of how you think the crescent should look. It will be extremely delicate and very tricky to see. Be sure to stop looking before the Sun rises.

Harvest Moon 2022

BEST TIME TO SEE: Moonrise on 8–12 September and 7–11 October

The Moon is full at 11:00 BST (10:00 UT) on 10 September, the closest full Moon to the Northern Hemisphere's autumn equinox, which is at 02:03 BST (01:03 UT) on 23 September. This makes it the Harvest Moon for 2022.

A Harvest Moon's proximity to the September equinox means that the rise times for the near-to-full phases of the Moon are nearly the same on the days before and after 10 September. It was the abundance of bright early-evening moonlight on those consecutive days that traditionally lit the fields for collecting the harvest.

It's an interesting exercise to note the rise time of the Moon on 8 September, then again on 9, 10, 11 and 12 September, calculating the differences. Waiting for the fuller phases of the Moon to rise is a great way to experience the visual effect of the Moon illusion, which makes these phases appear enormous when close to the horizon. The full Moon on 9 October is just a couple of days further away from the equinox than September's and you'll observe a similar pattern in the rise times for its fuller phases.

The period close to the March equinox represents the opposite situation, with the difference between successive moonrises for the fuller phases of the Moon being the largest of the year.

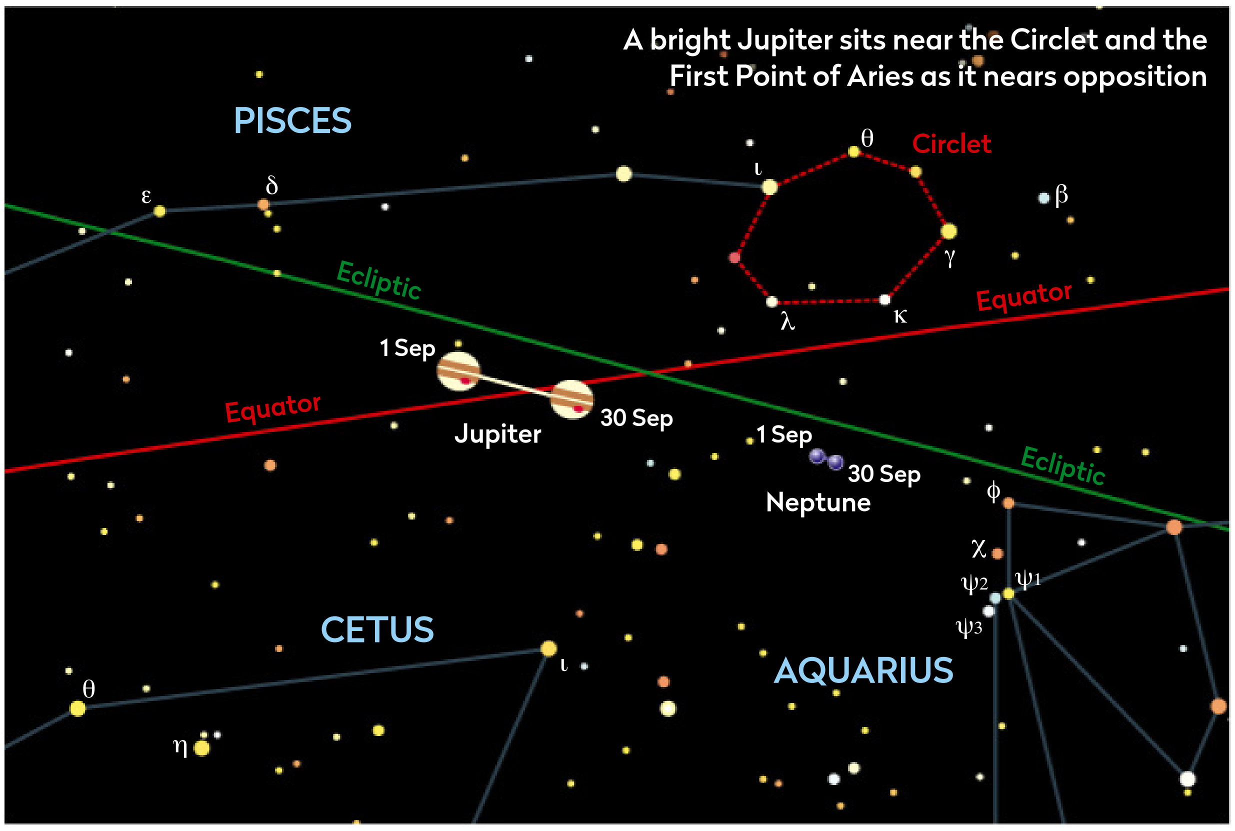

Track the unusually similar moonrise times either side of the Harvest Moon

THE PLANETS Our celestial neighbourhood in September

PICK OF THE MONTH

Jupiter

Best time to see: 26 September, 00:00 UT
Altitude: 37˚
Location: Pisces
Direction: South
Features: Detail of the planet's atmosphere, Galilean moons
Recommended equipment: 75mm or larger



A bright Jupiter sits near the Circlet and the First Point of Aries as it nears opposition

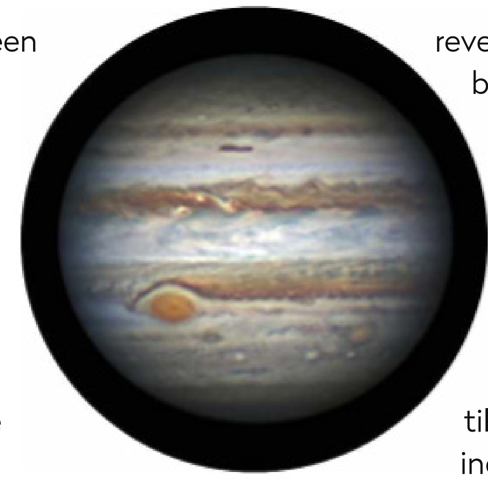
Jupiter will reach opposition on 26 September and, when viewed through the eyepiece, appears brightest and largest for this period of observation. Reaching an impressive mag. –2.8, it slips from Cetus into Pisces throughout September, the planet located east of the faint but distinctive Circlet asterism.

A bright full Moon lies near to Jupiter on the nights of 10 and 11 September, an impressive sight if you have clear skies. As they rise above the eastern horizon early evening on 11 September, Jupiter and the Moon will appear a little over 3˚ apart.

On opposition night, it sits 4˚ east of the First Point of Aries, one of two intersections in the sky where the celestial equator and the ecliptic cross. The First Point of Aries marks the start of the RA coordinate system (00h00m00s). Jupiter shines at mag. –2.8 on opposition night, reaching a peak altitude of 37˚ as seen from the centre of the UK.

Jupiter rotates quickly, the planet completing one rotation in under 10 hours. This brings atmospheric features into and out of view surprisingly quickly. A 100mm or larger telescope will show the planet's famous Great Red Spot, the appearance of which can be determined using the freeware WinJupos application (**jupos.org/gh/download.htm**).

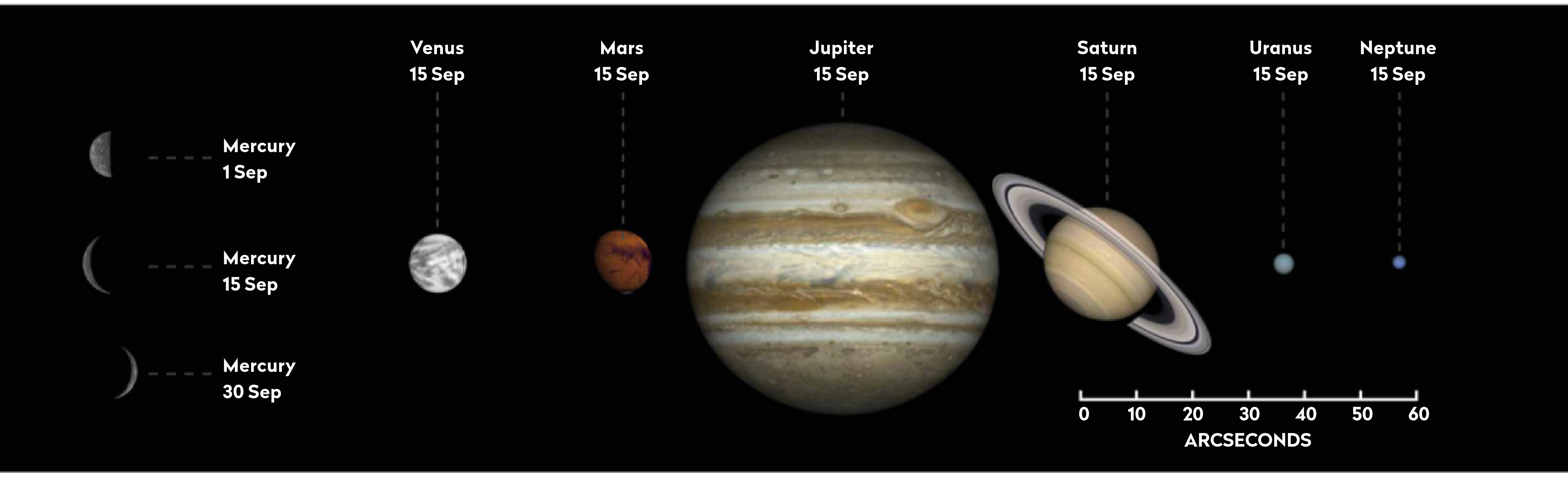
In addition to the planet's detailed atmosphere, a small telescope will also reveal the four largest and brightest Jovian moons, the so-called Galilean moons: Io, Europa, Ganymede and Callisto. The inner three can appear to pass in front of and behind the planet, but Jupiter's apparent tilt from Earth has now increased such that Callisto appears to miss the disc, although its shadow can still clip Jupiter's southern pole. This phenomenon can be observed on 5 September between 00:30 BST (23:30 UT on 4 September) and 01:47 BST (00:47 UT).


▲ Larger instruments will reveal the planet's swirling atmosphere

PETE LAWRENCE X 2

The planets in September

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 30 September, 30 minutes before sunrise
Altitude: 5° (low)
Location: Virgo
Direction: East
Mercury's position in the evening sky is poor at the start of September, appearing dim and setting shortly after sunset. Inferior conjunction is on 23 September. Mercury then reemerges into the morning sky where it becomes easier to see. By the end of the month, it shines at mag. +1.8 and rises 70 minutes before the Sun.

Venus

Best time to see: 1 September, 30 minutes before sunrise
Altitude: 7° (low)
Location: Leo
Direction: East-northeast
Shining at mag. –3.8 on 1 September, Venus can be seen rising above the east-northeast horizon 90 minutes before the Sun. Telescopically, it isn't well presented, at 10 arcseconds across and nearly fully illuminated. By the end of the month, Venus's position degrades further and it becomes harder to see, rising 40 minutes before sunrise.

Mars

Best time to see: 30 September, 04:50 UT
Altitude: 59°
Location: Taurus
Direction: South
Mars shows dramatic changes as it approaches opposition on 8 December. On 1 September, shining at mag. –0.1, it is located just north of the Hyades. Through a telescope the planet is 9 arcseconds across on 1 September, increasing to 11 arcseconds and mag. –0.6, a beacon between the horns of Taurus, by the month's end. A 58%-lit waning gibbous Moon lies 3° north of Mars on the morning of 17 September.

Saturn

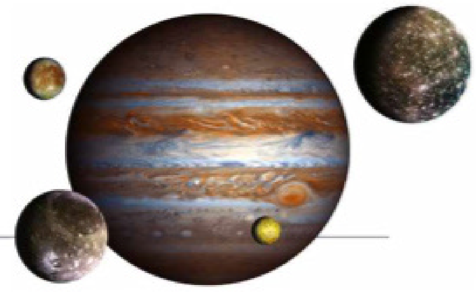
Best time to see: 1 September, 23:00 UT
Altitude: 21°
Location: Capricornus
Direction: South
Following opposition on 14 August, Saturn remains well placed all month, dropping in brightness only slightly from mag. +0.4 on 1 September to +0.6 by the end of the month. A bright waxing gibbous Moon sits nearby on the nights of 7/8 and 8/9 September.

Uranus

Best time to see: 30 September, 02:30 UT
Altitude: 54°
Location: Aries
Direction: South
Morning planet Uranus is perfectly placed for UK observation, able to reach an altitude of around 50° under dark skies. Visible as a green-hued mag. +5.7 disc through the eyepiece, a rare lunar occultation of Uranus takes place on the evening of 14 September. See page 46.

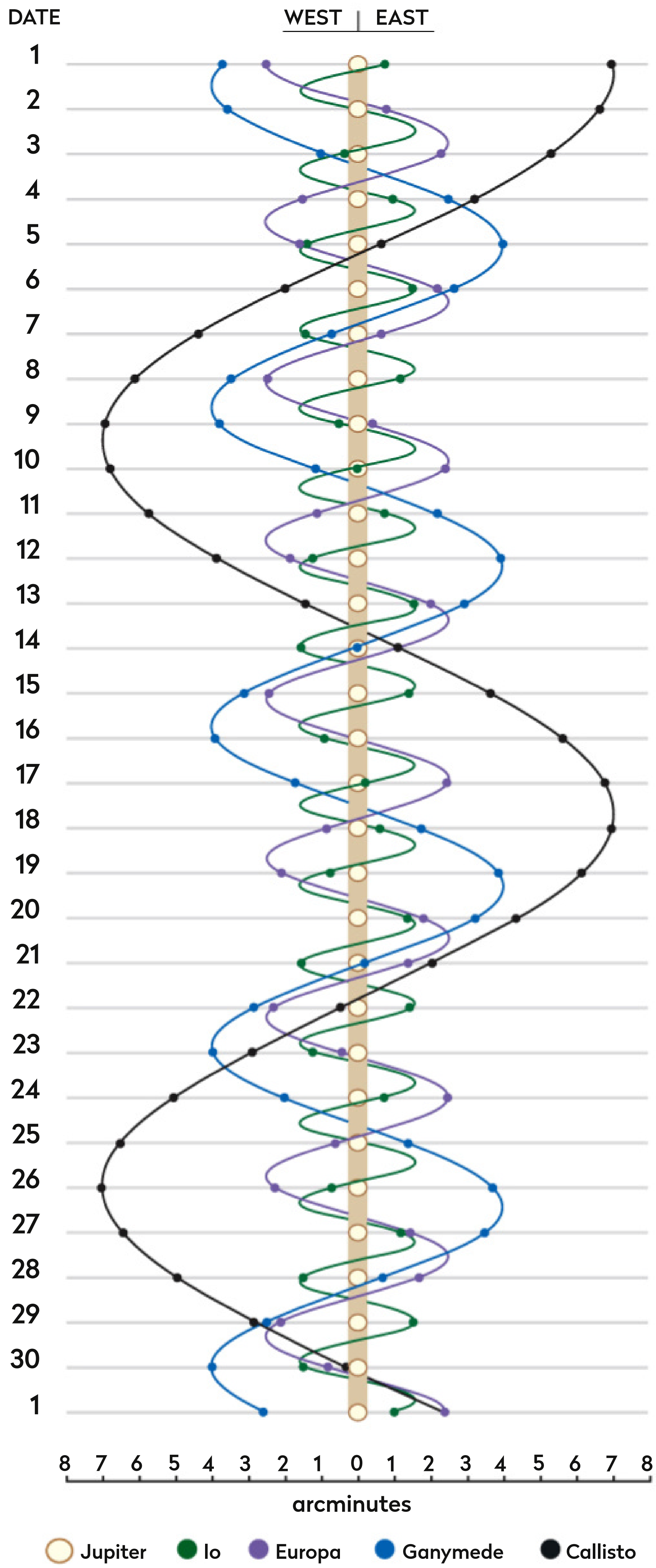
Neptune

Best time to see: 16 September, 00:15 UT
Altitude: 34°
Location: Aquarius
Direction: South
Neptune reaches opposition on 16 September, but at its great distance from Earth this usually favourable position has very little effect on the planet's visual appearance. Able to reach an altitude around 30° under dark sky conditions all month long, you'll need at least binoculars to spot mag. +7.8 Neptune.



JUPITER'S MOONS: SEP

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – SEPTEMBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

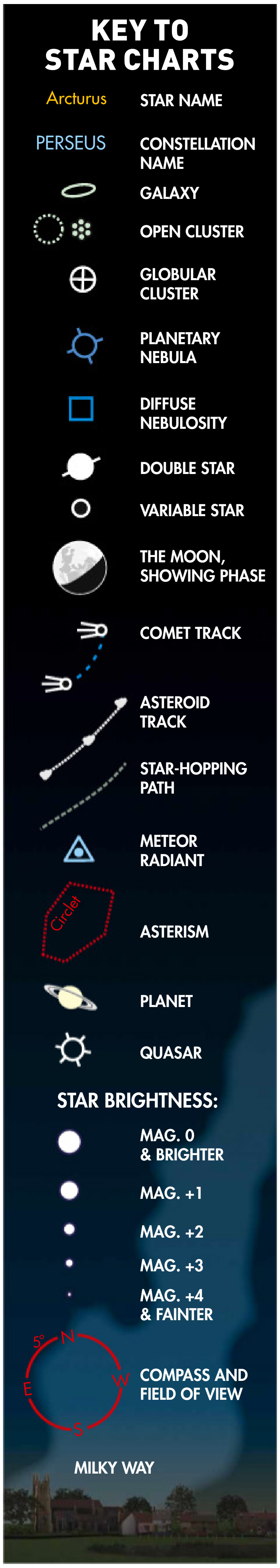


CHART: PETE LAWRENCE

When to use this chart

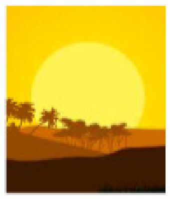
1 September at 01:00 BST
15 September at 00:00 BST
30 September at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in September*



Date	Sunrise	Sunset
1 Sep 2022	06:19 BST	20:00 BST
11 Sep 2022	06:36 BST	19:36 BST
21 Sep 2022	06:54 BST	19:11 BST
1 Oct 2022	07:11 BST	18:47 BST

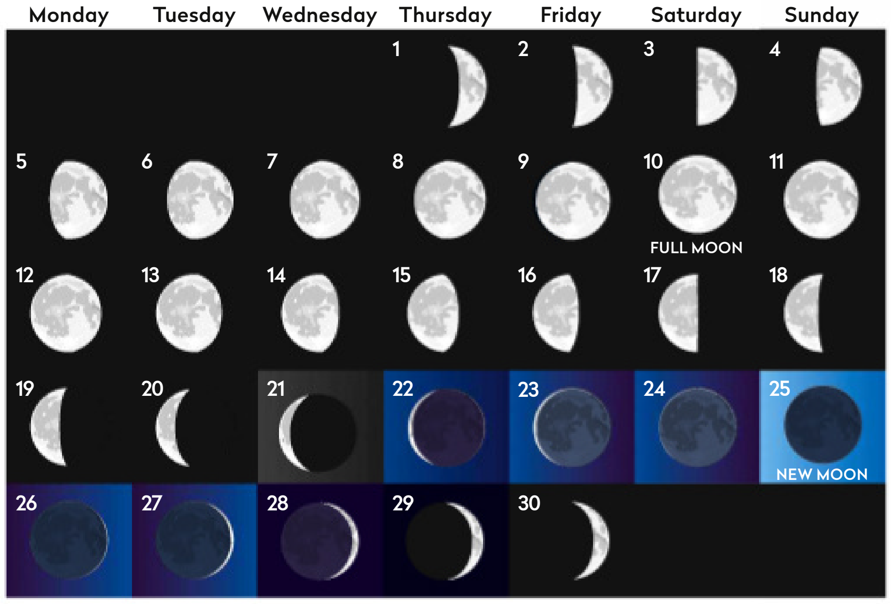
Moonrise in September*

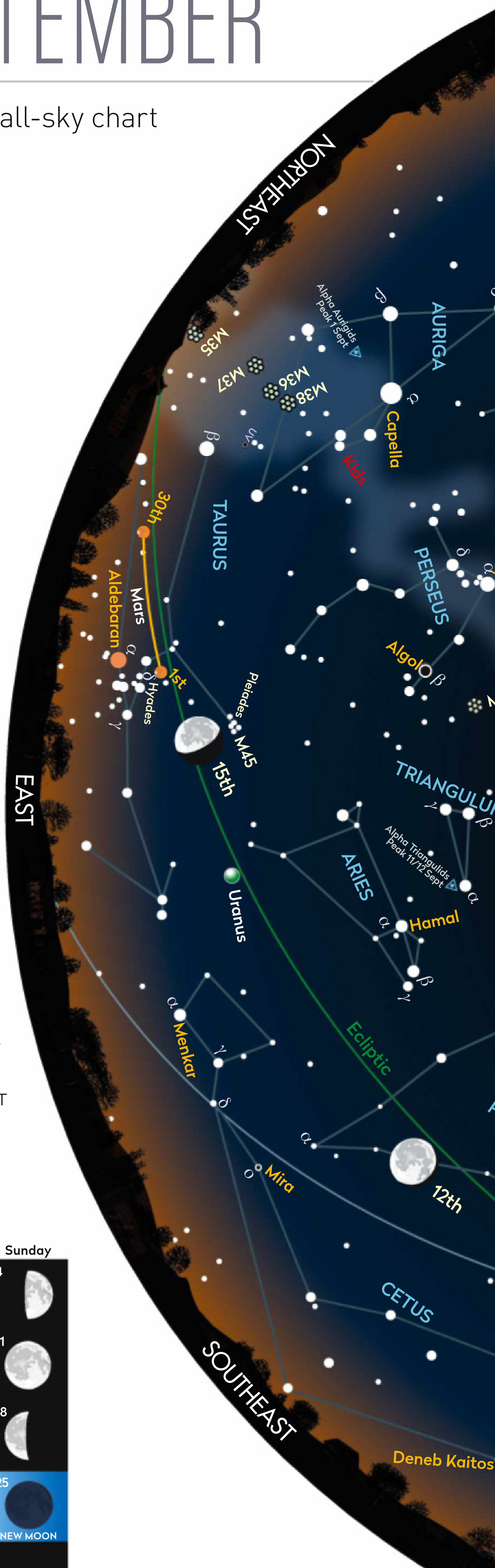
Moonrise times

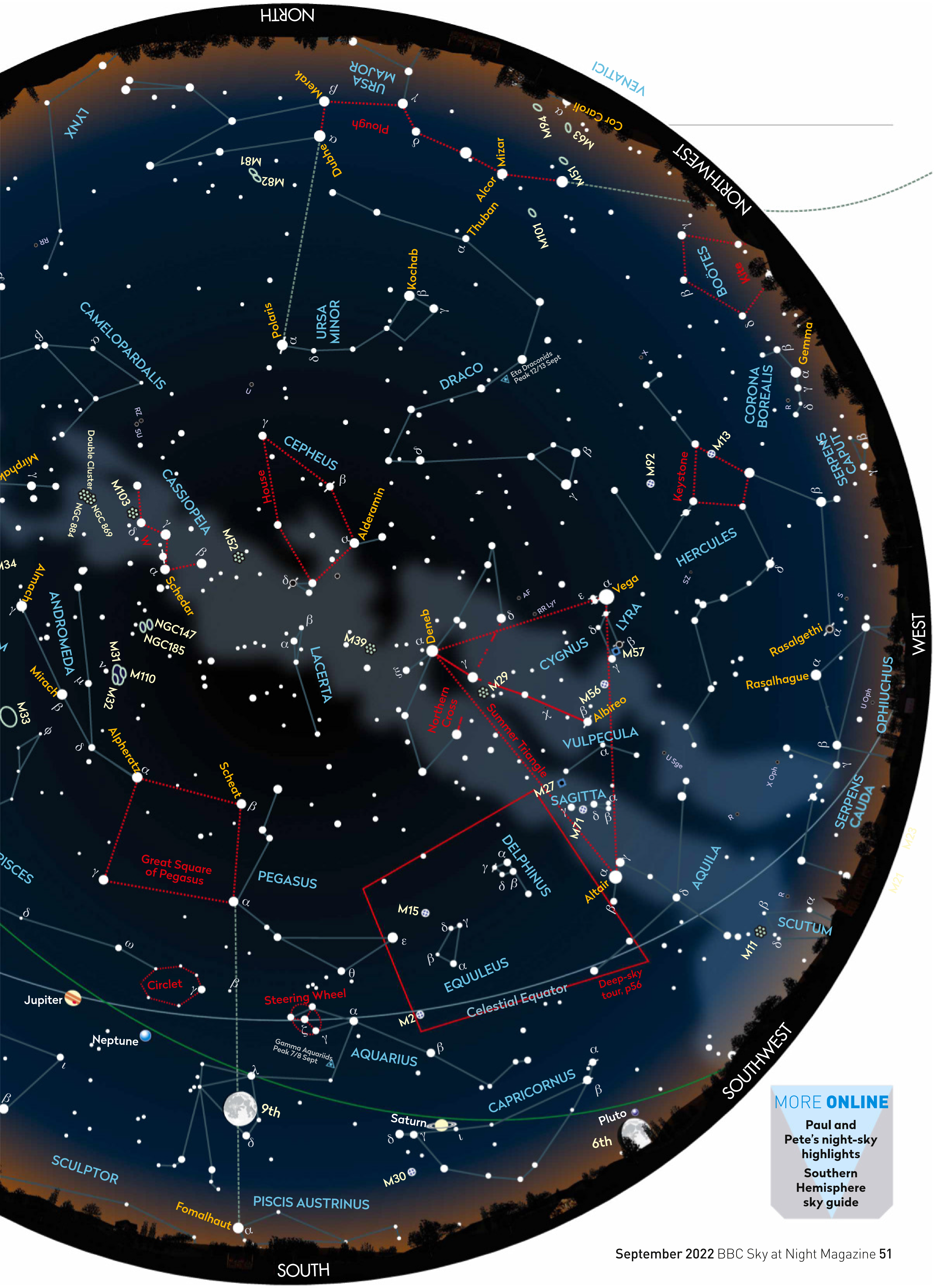
1 Sep 2022, 12:21 BST
5 Sep 2022, 17:48 BST
9 Sep 2022, 19:55 BST
13 Sep 2022, 20:42 BST
17 Sep 2022, 22:10 BST
21 Sep 2022, --:-- BST
25 Sep 2022, 06:05 BST
29 Sep 2022, 11:34 BST

*Times correct for the centre of the UK

Lunar phases in September



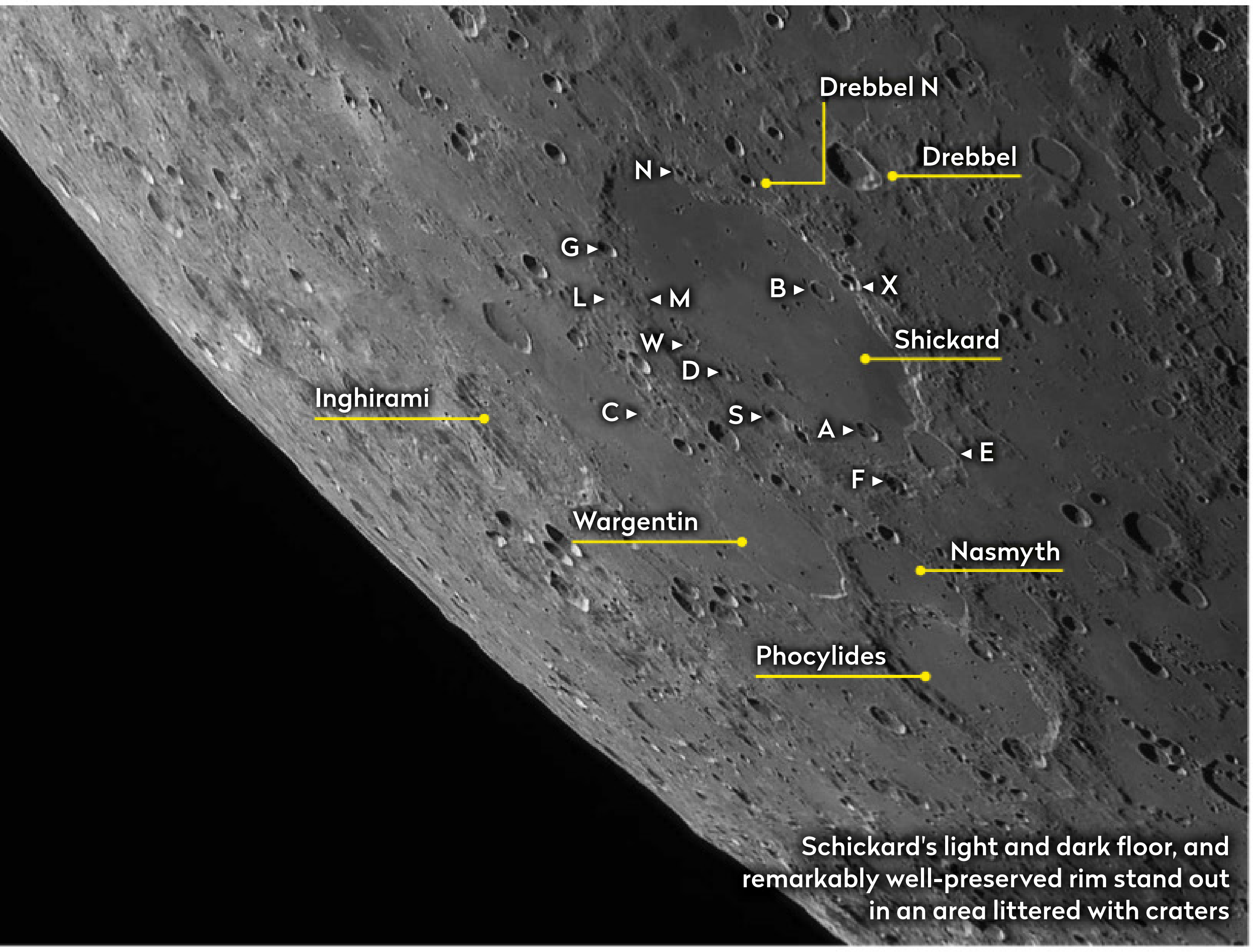




MORE ONLINE
Paul and Pete's night-sky highlights
Southern Hemisphere sky guide

MOONWATCH

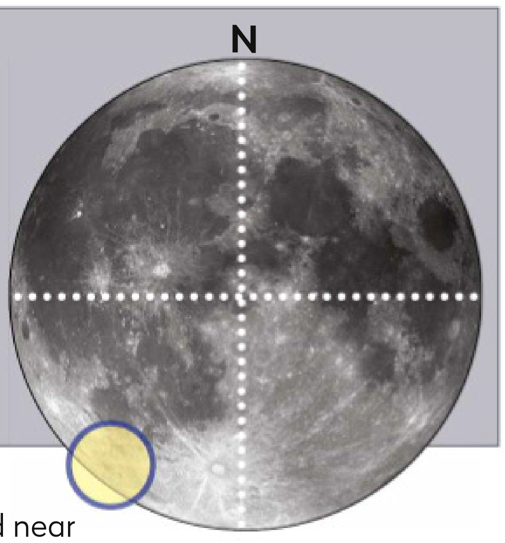
September's top lunar feature to observe



Schickard's light and dark floor, and remarkably well-preserved rim stand out in an area littered with craters

Schickard

Type: Crater
Size: 227km
Longitude/latitude: 55.1˚ W, 44.4˚ S
Age: Older than 3.92 billion years
Best time to see: Five days after first quarter (7–9 September) or four days after last quarter (21–22 August)
Minimum equipment: 10x binoculars



Schickard is an impressive crater located near the Moon's southwest limb. It lies within a densely packed region of lunar highlands surrounded by a multitude of smaller craters, managing to hold its own by virtue of its variegated floor.

Its appearance is heavily foreshortened thanks to its proximity to the Moon's edge, a vast walled plain created by an ancient rim surrounding a flat floor pockmarked by numerous craterlets. The largest of these are **Schickard A, B and C**, which have respective diameters of 14km, 13km and 13km, again heavily foreshortened into an elliptical appearance as seen from Earth.

The floor is variegated, meaning it consists of different coloured regions. The north third appears dark with much of what lies to the south light, save for a patch approximately one-sixth the total area in the southeast. which again appears dark. The three largest interior craterlets all sit within the lighter band.

Schickard's rim is remarkably well preserved considering the crater's age. The rim boundary is easy to follow except towards the south where things get a little messy, with the southern portion of the rim interrupted by the irregular-shaped and flat-floored crater 32km **Schickard E**.

A lot of satellite craters are scattered around the rest of the rim. Travelling clockwise from E there are: 17km F, 15km S, 5km D, 7km W, 7km M, 7km L, 12km G, 6km N and 8km X. The 9km crater between N and X is **Drebbel N**, associated with 30km Drebbel, an irregular-shaped, flat-floored crater to the northeast of Schickard.

To the southeast of Schickard lies a trio of large craters, one of which looks quite odd. The trio are 85km **Wargentin**, 78km **Nasmyth** and 114km **Phocylides**. It's Wargentin that looks odd, especially when you're wandering across this area with a low- to mid-power eyepiece. The oddness comes from the fact that it looks like it's lit from the opposite direction to the other craters. This occurs because in its past Wargentin has flooded due to lava forcing up through its floor. However, unlike most other flooded craters, Wargentin has managed to contain its copious amount of invading lava, with the result that it has filled up to the lowest point of its rim. If anything, it resembles more of a flooded plateau than a flooded crater.

Located 320km to the west-southwest of Schickard is 91km **Inghirami** which looks more like a regular crater. Inghirami is another flat-floored crater, but this time the floor is quite undulating, covered in a multitude of bumps. Estimated to be around 3.9 million years old, like Schickard, Inghirami's rim has fared well, the crater's form undisturbed and easy to pick out. Inghirami sits even closer to the Moon's edge than Schickard and consequently appears even more foreshorted into an elliptical shape. The foreshortening of this area has a big effect on distance here too: it is 320km, centre-to-centre, between Schickard and Inghirami, but they look relatively close together from the perspective of the Earth. For comparison, the north-south dimension of Schickard is unaffected by foreshortening and represents 227km, or 70% of the distance, centre-to-centre, from Schickard to Inghirami.

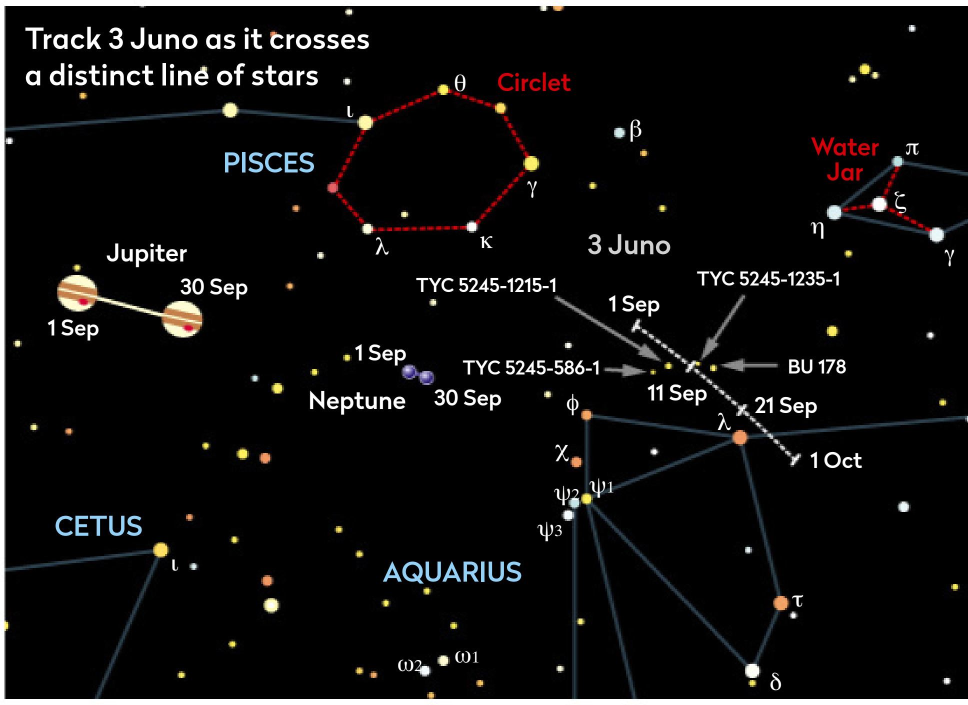
Schickard has an ancient rim surrounding a flat floor pockmarked by craterlets

PETE LAWRENCE X 3

COMETS AND ASTEROIDS

The 11st-largest asteroid, 3 Juno, reaches opposition this month

Track 3 Juno as it crosses a distinct line of stars



Minor planet 3 Juno reaches opposition on 8 September, a time when it appears to the southwest of the faint, yet surprisingly distinctive, Circlet asterism in Pisces. On 1 September, 3 Juno is in Pisces, around 5° below the midpoint of a line between the Circlet and another famous asterism further to the west, the Water Jar. Shining at mag. +8.1, Juno crosses the border from Pisces into Aquarius on 3 September.

Juno brightens to mag. +7.8, the same as the planet Neptune, on 7 September, holding this brightness until 9 September after which it slowly begins to dim once more. By the end of September, Juno will have dimmed to mag. +8.4. This means it's a viable binocular target throughout the month, and eminently suitable for tracking through a small telescope.

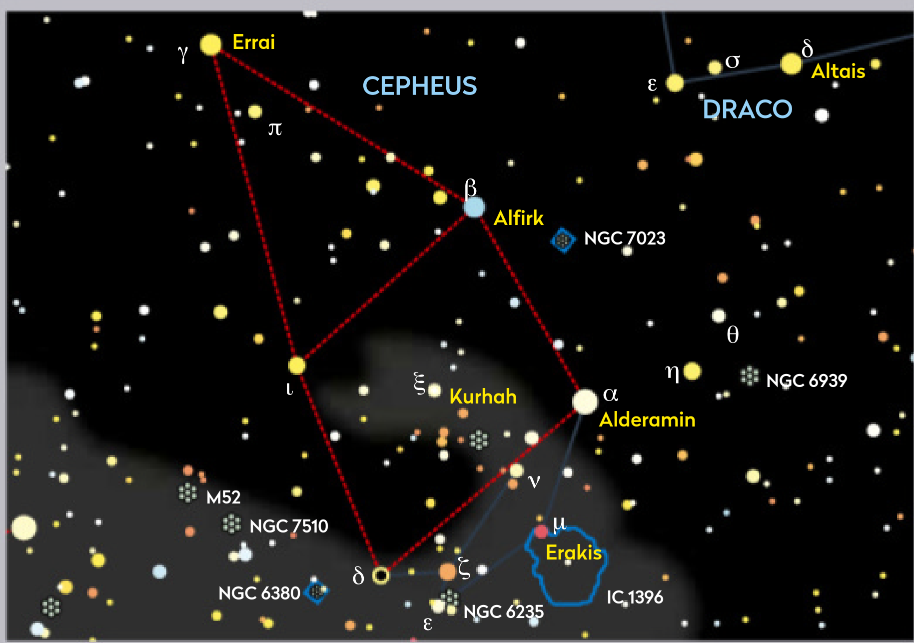
The comparison in brightness to Neptune is particularly apt as this distant main planet sits about 10° to the east of 3 Juno when both worlds share a similar brightness. The brightest guide star in the area is mag. +3.7 Lambda (λ) Aquarii, Juno appearing around 7° to its northeast on 1 September. It then tracks southwest, appearing 1° northwest of Lambda (λ) Aquarii on 21–23 September. Between 10 and 13 September, 3 Juno appears to cross a roughly 3°-long, bent line of faint stars formed from mag. +6.7 TYC-5245-586-1, mag. +5.8 TYC-5245-1215-1, mag. +6.3 TYC-5238-1235-1 and mag. +5.8 BU 178. These provide a good location aid.

Juno is the 11th largest asteroid and the second largest stony (siliceous or S-type) asteroid, with an estimated 1% of the entire mass of the asteroid belt. Its elliptical orbit is highly eccentric and takes it out to 3.35 AU (Astronomical Units) from the Sun at aphelion and as close as 1.99 AU at perihelion. The entire orbit takes 4.36 years to complete and is inclined with a tilt of 12° to the ecliptic.

STAR OF THE MONTH

Alderamin, the brightest star in Cepheus

▼ Look for a child's drawing of a house in the sky and you'll spot the constellation Cepheus



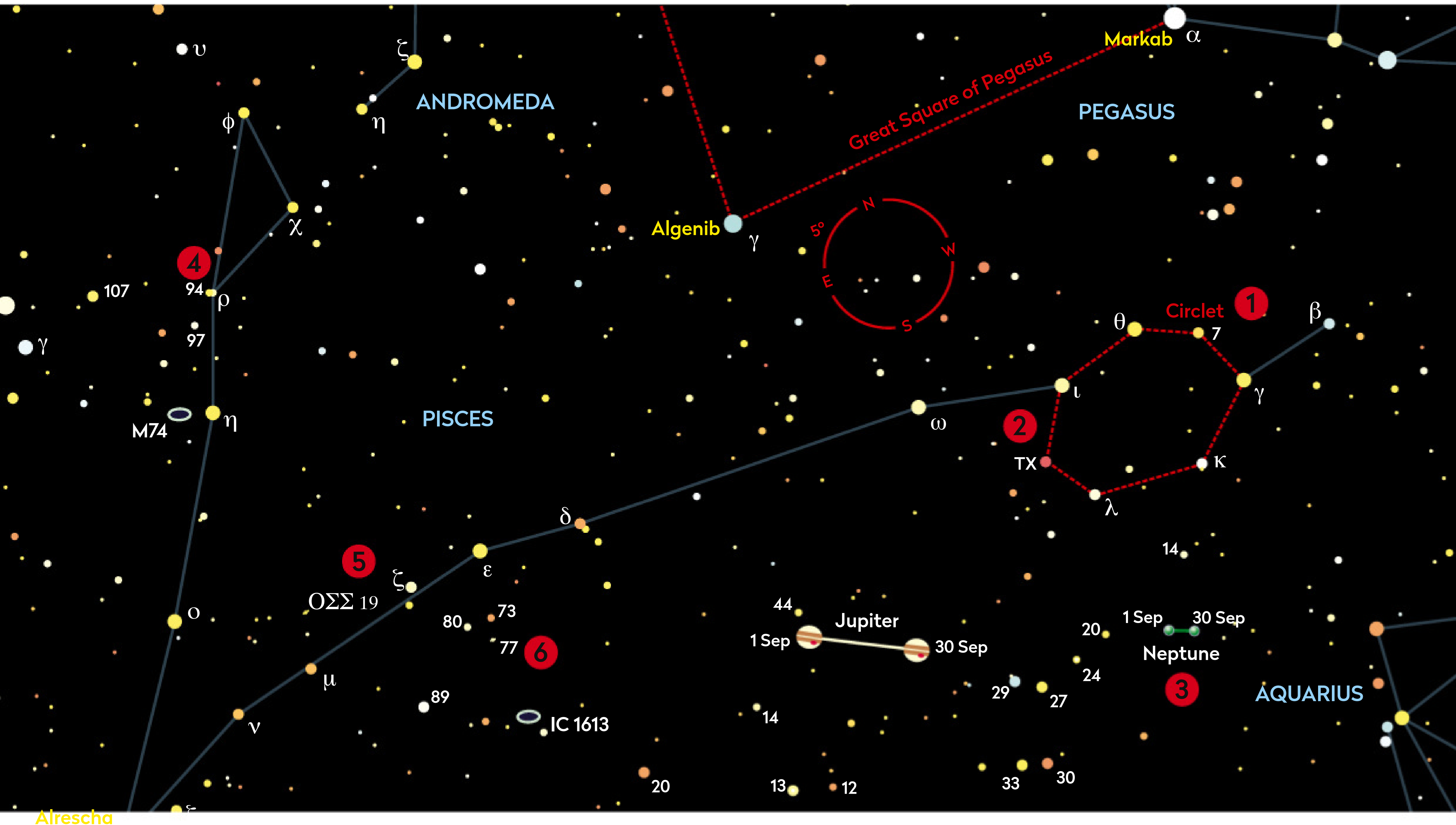
Although Cepheus represents a mythical king in the sky, the constellation is more frequently described in terms of its shape: it resembles the outline of a house formed from a square base and pointed roof. The bottom-right corner of the base (southwest corner) is mag. +2.4 Alderamin (Alpha (α) Cephei). This is one of our nearer neighbours, lying at a distance of 49 lightyears. The name Alderamin translates as 'the right arm'.

Alderamin is a white star of spectral class A8Vn, 'A8' placing it in the blue-white spectral region, closer to the white or yellow-white end. 'V' indicates it's a main sequence dwarf, the 'n' indicating that its spectrum contains broad absorption lines caused by a fast spin-rate. With a physical size 2.5 times larger than the Sun, the spin-rate for this star is high, one rotation taking just 12 hours. This translates to a rotational velocity around 283 km/s, compared to the Sun's rather leisurely 2km/s. An alternative spectral designation for Alderamin is A7V–IV, which hints that it's moving off the main sequence branch and evolving into a subgiant (the 'IV' designation), something that happens when hydrogen fusion in a star's core begins to wane.

Located around 3° from the North Celestial Pole, Alderamin was the pole star around 18,000 BC and will be again in another 5,500 years. Alderamin emits a similar amount of X-radiation as the Sun, something which is unexpected for an A-class star such as this. The reason is likely the rapid rotation rate which gives rise to huge convective currents within the star's interior.

BINOCULAR TOUR With Steve Tonkin

A spin around the Circlet, pop in on Neptune and try to split some doubles



1. The Pisces Circlet

10x50 You can see the seven-star circlet of Pisces in a dark sky with your unaided eye. There are no particularly bright stars in the constellation, but mag. +3.7 Kappa (κ) Piscium is one of the brighter ones, and others in the Circlet range in magnitude between that and mag. + 5.1 7 Piscium. Binoculars help to bring out the colours of the stars which, with one exception, are in adjacent pairs of similar colours. ☐ **SEEN IT**

2. TX Piscium

10x50 The exception to the adjacent pairs found in the Circlet is the easternmost star, the slightly variable (ranging from mag. +4.8 to mag. +5.2) TX Piscium, which is one of the reddest stars that is easily visible with 50mm binoculars. TX Piscium is a carbon star: it pulsates in size and throws off layers of soot as it contracts, causing it to dim slightly. It displays a phenomenon called the Purkinje effect, appearing to brighten as you look at it. ☐ **SEEN IT**

PETE LAWRENCE X 3

3. Neptune

10x50 A little more than 5° south of the Circlet you'll find Neptune, just west of mag. +5.5 20 Piscium, shining at mag. +7.8 and being indistinguishable from a star in 10x50 binoculars. There are some stars of similar brightness in the immediate vicinity, but an easy way to ensure that you have identified this ice giant is to observe the region several times, a few days apart, and note which 'star' appears to have wandered slightly. ☐ **SEEN IT**

4. Rho and 94 Piscium

10x50 The final three objects of our tour are all double stars. The easiest of these is the pair mag. +5.4 Rho (ρ) Piscium and mag. +5.5 94 Piscium. They are separated by 7.5 acrminutes so, if the sky is dark enough for you to observe them, you should be able to see space between the two stars. Binoculars counteract the loss of stars due to skyglow, and also show you that 94 Piscium is the more orange of the two. ☐ **SEEN IT**

5. OΣΣ 19

15x70 Our next pair lies 2° north of mag. +4.8 Mu (μ) Piscium. The OΣΣ in its signifier tell us that it was catalogued by the 19th-century astronomer Otto Wilhelm von Struve. The stars of this pair have similar colours to those of our previous target, but there the similarity ends. They are separated by only 69 arcseconds and are very obviously of unequal brightness, being of mag. +6.2 and +8.0. ☐ **SEEN IT**

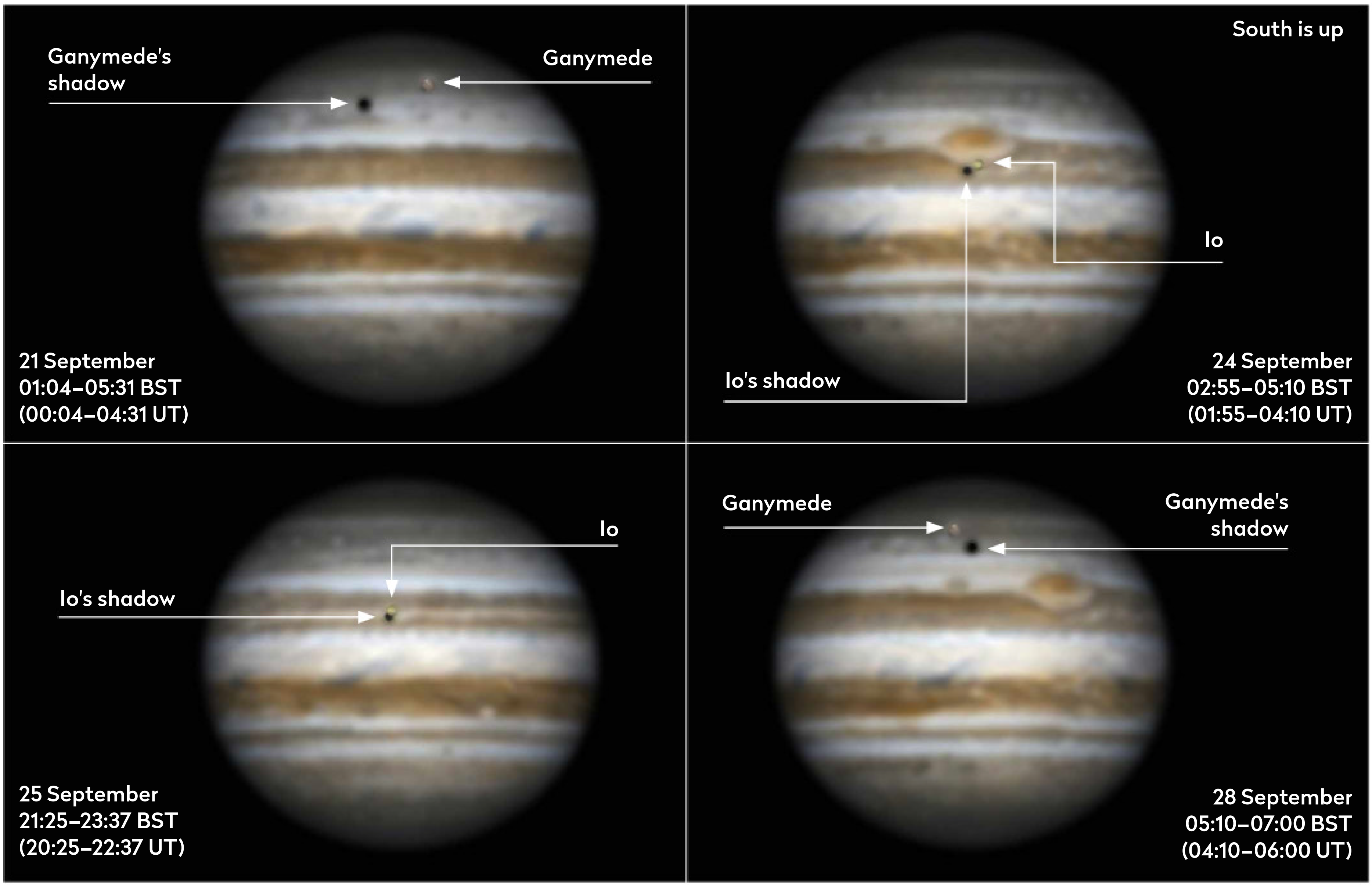
6. 77 Piscium

15x70 We complete the tour with a more challenging pair. A little more than 2° south of mag. +4.3 Epsilon (ε) Piscium lies a little triangle of stars of approximately 6th magnitude. The faintest and most southerly star of the triangle is mag. +6.4 77 Piscium, and your binoculars will show its mag. +7.2 companion a mere 33 arcseconds to the east. These two stars differ in brightness, but note how they have identical colours. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Observe how the shadows of the Jovian moons shift around at opposition



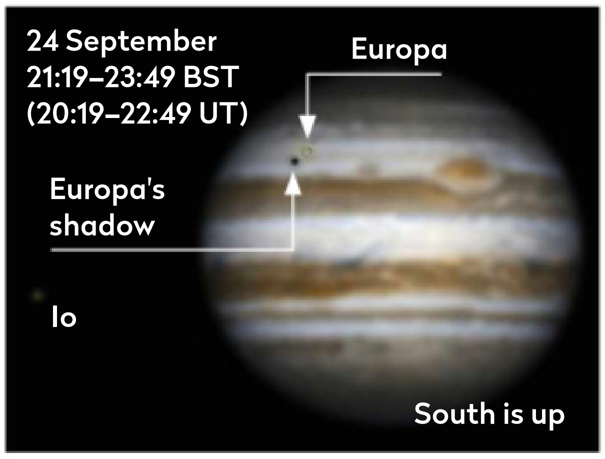
▲ **Ganymede and Io's shadows will precede then follow their moons around opposition. Io and its shadow will overlap on 25 September**

The planet Jupiter reaches opposition on 26 September, a term which describes when a planet is on the opposite side of the sky to the Sun. This month's challenge is to see some effects visible around the time of Jovian opposition. We would recommend using a 75mm or larger telescope, with a minimum magnification of 100x. The larger the telescope, the clearer the view.

Jupiter reaches perihelion on 25 January 2023, when it will be closest to the Sun in its orbit. This means that Jupiter's 2022 and 2023 oppositions will be particularly good as seen from Earth, the planet appearing at its brightest and largest for some time. Opposition also has an effect on the appearance of its four largest Galilean moons because as they transit across the Jovian disc, they are closely accompanied by their shadows.

Before opposition, a moon's shadow will appear to precede the moon. After opposition, a shadow will follow its moon. At the time of opposition itself, the shadow and moon appear in sync, moving across Jupiter together.

Catching this moment, when a moon and its shadow are exactly at opposition, is a matter of luck with timing and often doesn't work out. However, there are normally a few events visible in the days before and after opposition when the sync is still pretty close. On 21 September, the giant moon Ganymede is preceded by its shadow. This can be seen from 01:04 BST (00:04 UT) through to 05:31 BST (04:31 UT). Then on 24 September, Io transits with its shadow fractionally ahead of its disc between 02:55 BST (01:55 UT) and 05:10 BST (04:10 UT).



▲ **Europa's shadow will be slightly ahead of its moon during 24 September's transit**

Also on 24 September, there's a chance to see Europa and its shadow passing across the Jovian disc between 21:19 BST (20:19 UT) and 23:49 BST (22:49 UT). Here Europa and its shadow will appear close but separated, the shadow fractionally ahead of the moon.

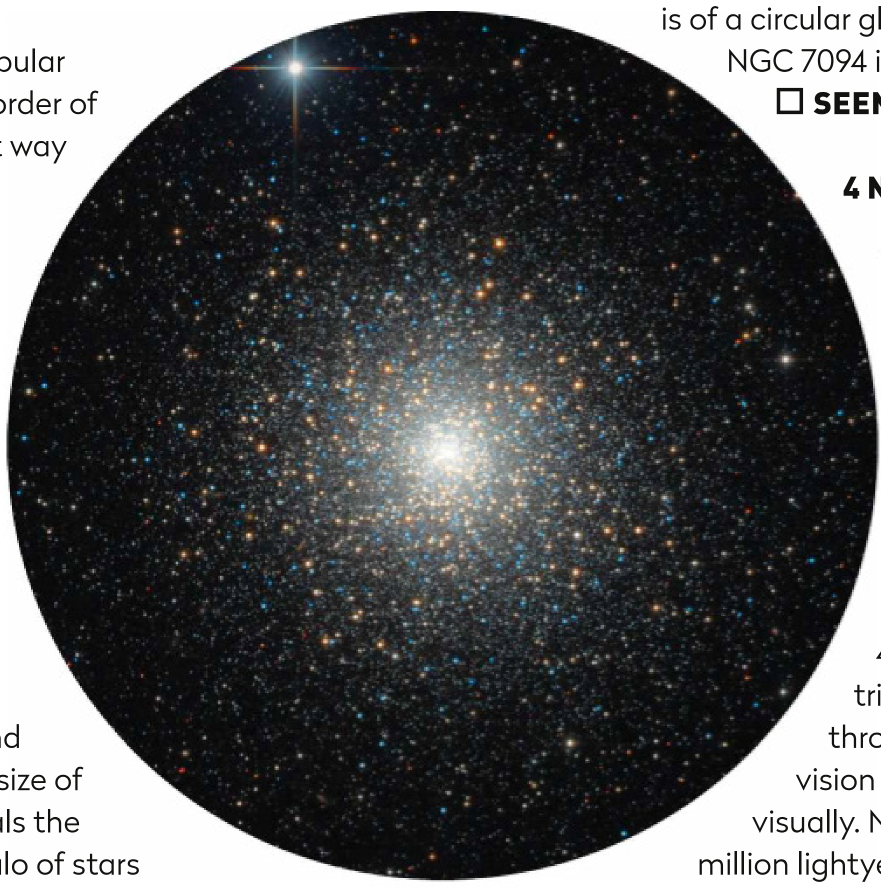
An excellent transit of Io and its shadow can be seen on the evening of 25 September starting at 21:25 BST (20:25 UT) and concluding at 23:37 BST (22:37 UT). Being very close to opposition, in this instance the moon and its shadow will be overlapped as they transit together. Then on the morning of 28 September, Ganymede crosses Jupiter's disc, this time followed by its shadow. This event runs from 05:10 BST (04:10 UT) until Jupiter sets around 07:00 BST (06:00 UT) as dawn breaks.

DEEP-SKY TOUR

This month we take a trip around the equine delights of Pegasus and Equuleus

1 M15

Messier 15 is a bright globular cluster located on the border of Pegasus and Equuleus. The easiest way to locate it is to identify the star marking the top of the upside-down flying horse's head, Baham (Theta (θ) Pegasi) and extending a line from it through the horse's nose marked by Enif (Epsilon (ε) Pegasi) for half the distance again. With an integrated magnitude of +6.3, M15 is easy to see in small instruments. A 150mm scope will show a 5-arcminute glow with a definite granular texture. M15 is highly concentrated towards its centre and this really shines through with any size of scope. A 250mm scope really reveals the bright core well, the surrounding halo of stars nicely resolved. ☐ **SEEN IT**



▲ Scopes of 250mm and above will make out the bright core of M15

Opposite page: the inset shows planetary nebula Pease 1 inside M15

2 Pease 1

If you're looking at M15 you're also looking at the next target, the planetary nebula Pease 1 which sits within the globular. It's the first such object found within a globular cluster and a great example to hunt with larger instruments over 200mm diameter. It's tiny at just 3 arcseconds across. It's also pretty faint, with an integrated magnitude of +15.5. To see it, wait until M15 is highest in the sky, due south. High powers of 450x or more are recommended, so fairly stable seeing is also needed. An OIII or Skyglow filter should help here, but applying them between eye and eyepiece ('blinking') may produce only subtle effects. ☐ **SEEN IT**

3 NGC 7094

Our next target is another planetary nebula, NGC 7094. This lies 1.8° to the east-northeast of M15 and although it's also fairly faint at mag. +13.7, it is larger than Pease 1, with a diameter around 1.6 arcminutes. It's visible with a 200mm scope but larger apertures and an OIII or UHC visual filter are highly recommended. The central star shines at 13th magnitude. You may need to watch magnification here too, as powers of 100x will show it well through larger apertures, but pushing beyond this tends to make it quite hard to see well. Its overall appearance is of a circular glow surrounding its central star. NGC 7094 is located 5,500 lightyears from us. ☐ **SEEN IT**

4 NGC 7042

Our next target is located 4.2° west-northwest of M15, on the border between Pegasus, Equuleus and Delphinus. NGC 7042 is a 13th-magnitude spiral galaxy. This is a tricky object even in a 300mm scope, appearing as little more than a faint smudge. It sits just to the west of a north-pointing, 4-arcminute-high isosceles triangle of faint stars. At 150x through a 300mm scope, averted vision is needed to see the galaxy visually. NGC 7042 is a distant object, 210 million lightyears from Earth. If you have a large-aperture scope such as a light-bucket Dobsonian, try for the galaxy NGC 7043 as well. This is another spiral. At 14th magnitude, this is a tricky object to see. ☐ **SEEN IT**

5 NGC 7006

We hop over the border from Pegasus into Delphinus next, to globular cluster NGC 7006. To locate it, imagine the line from Enif to M15 and extend that line by twice the distance again. This is a distant globular, around 160,000 lightyears away, that's over 10 times further than M15. As a consequence, it appears small and relatively faint, with an integrated magnitude of +10.6. Through a 150mm scope, it's around 1 arcminute across: a haze with a definite core. A 250mm scope shows it as a larger object with no resolved members, but mottled granularity. A 300mm scope will begin to show some of the outer stars at high magnification. ☐ **SEEN IT**

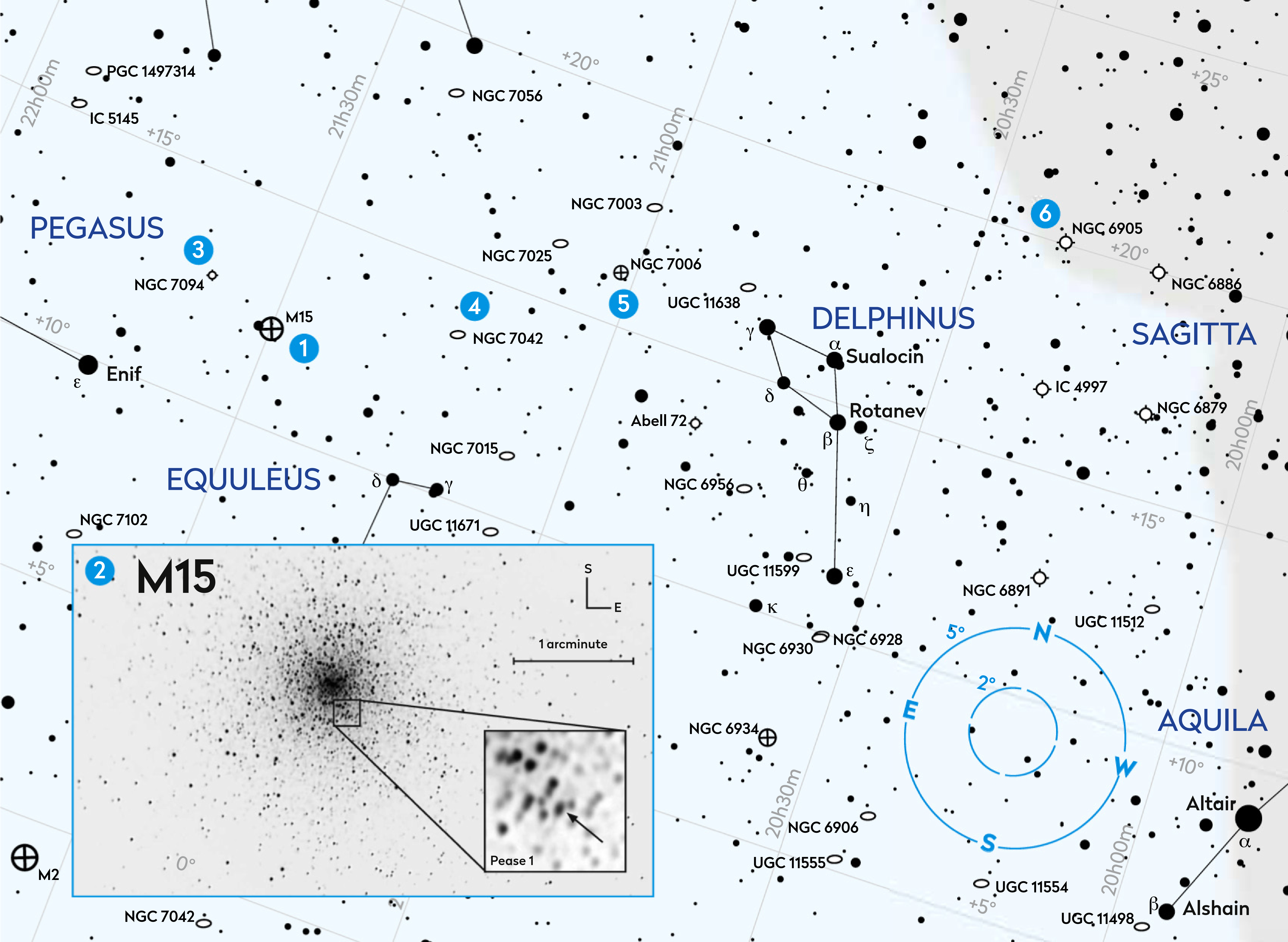
6 NGC 6905

Our final object is a planetary nebula. NGC 6905, also known as the Blue Flash Nebula, is located in the extreme northwest corner of Delphinus, where it borders Vulpecula and Sagitta. Locate it by drawing a line from the mid-point between Enif and M15, to NGC 7006 and extending that line for the same distance again. The nebula lies 7,500 lightyears away and shines with an integrated magnitude of +10.9. Its central star is dim at mag. +14.2 but shouldn't be too hard for a 300mm or larger scope. A small scope will have no problem revealing this object as a small circular glow, while a larger instrument will show it stretched slightly north–south, with a more mottled appearance, getting brighter towards the core. ☐ **SEEN IT**

BERNHARD HUBL/CCDGUIDE.COM, CHART BY PETE LAWRENCE

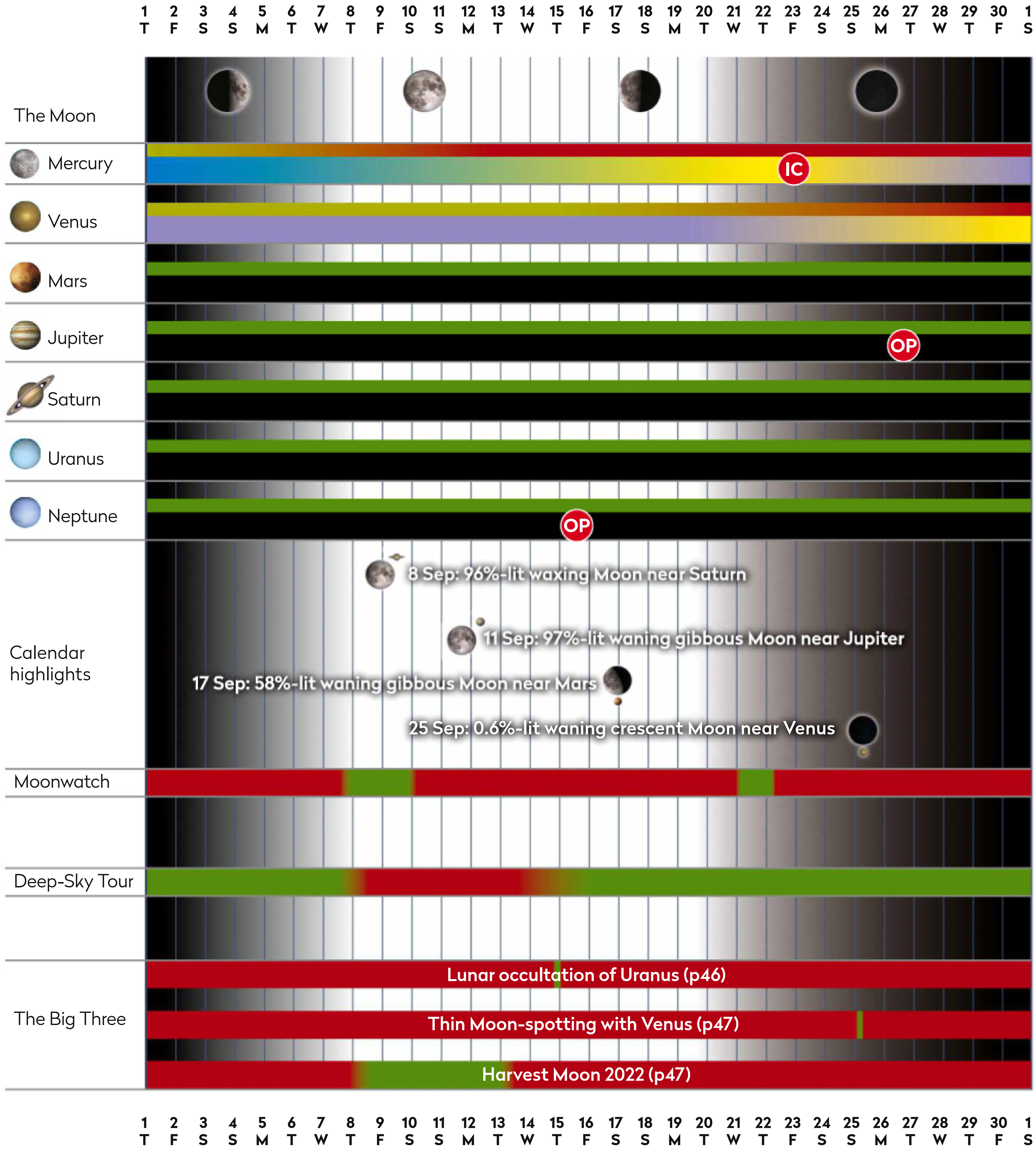
This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**
Print out this chart and take an automated Go-To tour. See page 5 for instructions.


PEGASUS
EQUULEUS
DELPHINUS
SAGITTA
AQUILA
PGC 1497314
IC 5145
NGC 7056
NGC 7094
M15
Enif
NGC 7025
NGC 7003
NGC 7006
NGC 7042
UGC 11638
Sualocin
Rotanev
Abell 72
NGC 7015
NGC 6956
NGC 7102
UGC 11671
UGC 11599
NGC 6930
NGC 6928
NGC 6934
NGC 6906
UGC 11555
UGC 11554
UGC 11498
UGC 11512
NGC 6891
NGC 6905
NGC 6886
IC 4997
NGC 6879
Altair
Alshain
M2
NGC 7042
M15
1 arcminute
S
E
Pease 1
N
E
S
W
5°
2°
22h00m
21h30m
21h00m
20h30m
20h00m
+25°
+20°
+15°
+10°
+5°
0°

AT A GLANCE

How the Sky Guide events will appear in September



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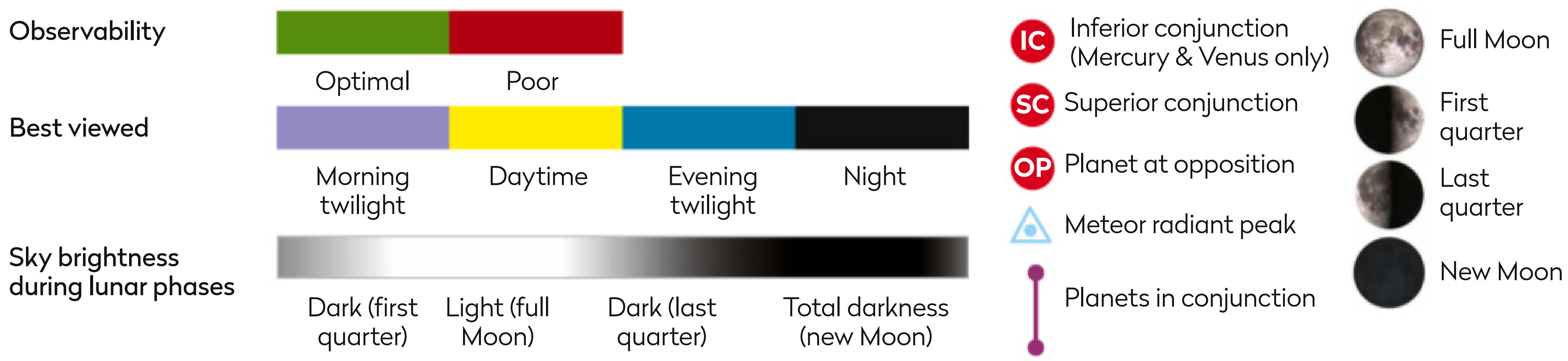


CHART BY PETE LAWRENCE

BERNHARD HUBL/CCDGUIDE.COM

Glittering ball of stars M92, often overlooked in favour of its glitzier neighbour M13, is in our rundown of the most stunning globular clusters to observe

Glorious GLOBULARS

From fuzzy blobs to star cities, **Paul Money** takes us on a tour of 15 of the best globular clusters to observe in this season's night skies

Fuzzy blobs – that's often what new stargazers viewing a globular cluster think when they spot their first one. It's true that these concentrations of ancient stars, ranging in number from tens of thousands to millions, can be a bit lacking in their visual impact with smaller instruments, not quite resembling the stunning images you'll regularly see online or in our Gallery pages. Yet, with care, a little more aperture, and yes, by capturing the objects with an astrophoto, a globular cluster's own 'personality' – the detail that makes them interesting and enjoyable to view – shines through.

All about globulars

You could argue that the first globular cluster seen was Omega Centauri, listed by Johann Bayer in his *Uranometria* in 1603. But that very designation belies the fact it was visible to the naked eye and considered a star. The first globular defined as a 'nebula' was accidentally discovered by the German amateur astronomer Abraham Ihle in 1665, one we now know as M22 in Sagittarius. More were quickly discovered, but their nature was still not properly understood. They were still described as nebulous patches or round spots of cloud until 1764, when Charles Messier resolved stars in M4.

William Herschel coined the term 'globular cluster' in 1786, when he found he could resolve the objects into clouds of stars. Herschel's revelation may stem not just from his visual acuity but from the growing apertures of the instruments at his disposal, mainly reflectors he produced himself.

Globulars form a halo around the Milky Way, centred on one side of the sky, close to the Sagittarius–Scorpius border. Observing them, Harlow Shapley used a type of variable star known as RR Lyrae stars to estimate their distances in 1914. Then, noting the clusters' distribution in 1918, he established a startling and vastly larger size for the Milky Way than was commonly accepted, along with the conclusion that the galactic centre lay in Sagittarius.

Today, globular clusters have been observed around all types of galaxies. Their origin is still up for debate, though one theory is that they formed in areas where the interstellar medium was particularly concentrated at an early epoch of the Universe. Sometimes even older than the galaxy they surround, their stars are typically 'metal poor', or lacking elements heavier than hydrogen and helium. To date, it is thought that globulars are not environments suitable for planetary formation, due to the lack of these elemental building blocks and the density of stars within them.

Despite their reputation as mere fuzzy blobs, globular clusters can range from tight, condensed cores to more loosely confined spheres of stars. They can be slightly flattened, have outer halos of fainter stars, curved trails of stars, coloured stars and dark features, which can be seen visually and photographically.

Globular clusters are enchanting objects if examined carefully with larger apertures. So come with us as we explore 15 of the most rewarding of these 'star cities' to observe in early autumn skies. ▸

Paul Money is an astronomy writer and broadcaster, and the reviews editor of *BBC Sky at Night Magazine*

1. Messier 3

Catalogue number: NGC 5272
Constellation: Canes Venatici
Magnitude: +6.3
Minimum equipment: 6-inch reflector; 3-inch refractor
M3 is one of the most scientifically studied of all globular clusters as it is unusual in being more metal-rich than most. In binoculars it is a hazy patch, while 4-inch refractors or 6-inch reflectors begin to show some of its stars. You may note that there is a central concentration and a hazy outer region, with the cluster standing out as lying inside a triangle of stars. Indeed the presence of the cluster turns the triangle into a 'Y'. To locate M3, take a line from Arcturus in Boötes and extend it to Cor Caroli in Canes Venatici. M3 is just short of halfway between the two stars.

2. Rose Cluster

Catalogue number: M5, NGC 5904
Constellation: Serpens
Magnitude: +5.6
Minimum equipment: 6-inch reflector; 3-inch refractor
M5 is technically a naked-eye object at magnitude +5.6 but it does require good vision and dark skies to see. It can be found close to the magnitude +5.0, naked-eye star 5 Serpentis, so if you can see a small 'cloud' next to this star, then you have it. In larger apertures, such as an 8-inch reflector, M5 has a compact core that is quite bright and has notable trails of stars that seem to curve and stream away from the centre, viewable with averted vision.

3. Messier 10

Catalogue number: NGC 6254
Constellation: Ophiuchus
Magnitude: +6.6
Minimum equipment: 6-inch reflector; 3-inch refractor
From a dark-sky site, M10 is an easy binocular target with a nearby companion globular, M12, the Gumball. M10 is located close to the magnitude +4.8 star 30 Ophiuchi, which is distinctly orange and hard to miss. M10 is round and brightens gradually towards its core, which some observers suggest looks pear-shaped.

Averted vision helps to bring out a faint halo of stars surrounding the core, while larger telescopes hint at a couple of star trails extending away from it.

4. Gumball Globular Cluster

Catalogue number: M12, NGC 6218
Constellation: Ophiuchus
Magnitude: +6.7
Minimum equipment: 6-inch reflector; 3-inch refractor
The Gumball is marginally fainter than its nearby companion M10 but that doesn't make it hard to find. This globular, M10 and 30 Ophiuchi can all be seen in the same 10x50 binocular field of view. M12 and M10 both lie at a similar distance from us and are genuine neighbours in space. An 8-inch reflector begins to resolve the Gumball as a loose core surrounded by a hazy halo of stars. With larger apertures, a dark V-like shape cuts into the core.

5. Messier 14

Catalogue number: NGC 6402
Constellation: Ophiuchus
Magnitude: +7.6
Minimum equipment: 8-inch reflector; 4-inch refractor
M14 is sometimes overlooked, yet it is a rewarding object. Find it with the help of the triangle shape it forms with Beta (β) Ophiuchi, Cebalrai and Nu (ν) Ophiuchi. M14 is the apex pointing towards M10. It is smaller than M10 and fainter, but quite compact. With greater magnification and aperture, a faint outer halo of stars comes into view.

FRANZ KLAUSER/CCDGUIDECOM, GÜNTER KERSCHHUBER/CCDGUIDECOM, DANIEL VERSCHATSE/ CCDGUIDECOM, BERNHARD HUBL/ CCDGUIDECOM X 4, CHART BY PETE LAWRENCE

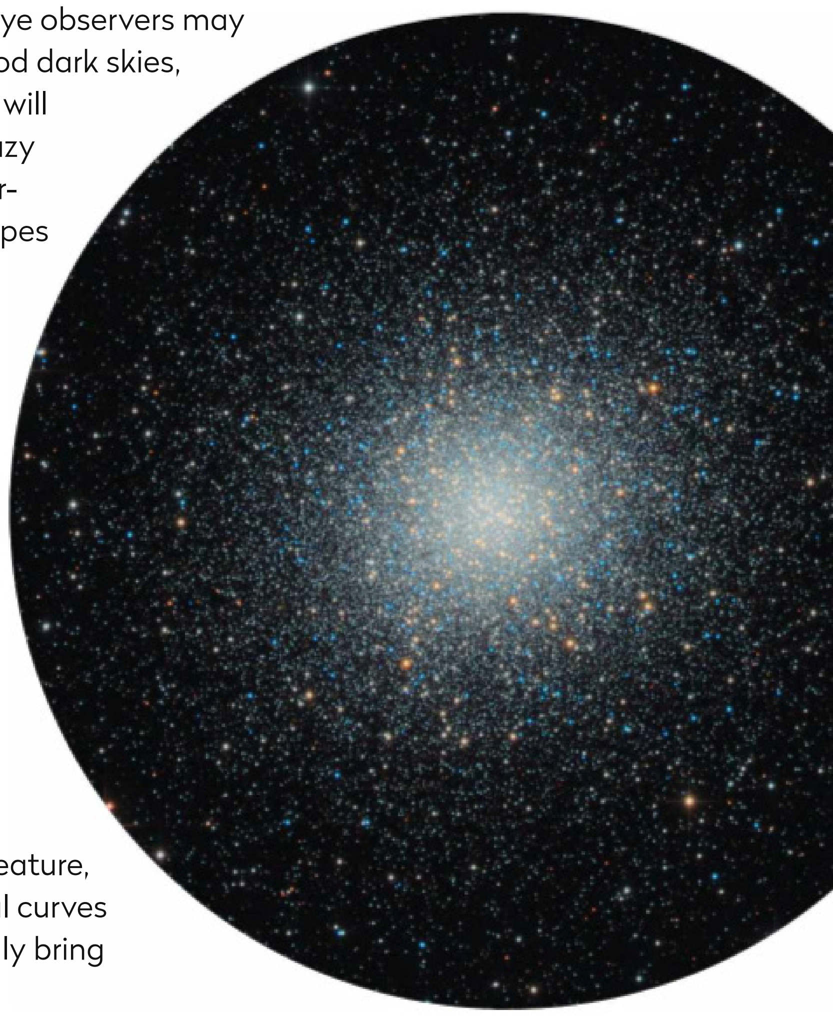
▲ Where to find our 15 glorious globular clusters in early autumn skies. The chart shows the view at 22:00 BST (21:00 UT) on 15 September

6. Messier 9

Catalogue number: NGC 6333
Constellation: Ophiuchus
Magnitude: +7.8
Minimum equipment: 8-inch reflector; 4-inch refractor
M9 is an oddball of a globular cluster – small and compact, yet dimmer than you might expect. Like M14, this could be due to several dark clouds in the vicinity that may be supressing the light of the cluster. There is little in the way of remarkable features here, but stick with it as larger apertures hint at a slightly oval core with a couple of curved stellar lines extending out from its edge.

7. Great Globular Cluster

Catalogue number: M13, NGC 6205
Constellation: Hercules
Magnitude: +5.8
Minimum equipment: 6-inch reflector; 3-inch refractor
Probably the best-known globular in the Messier Catalogue, M13 is easy to locate between the two main stars forming the western side of the 'Keystone' of Hercules, Eta (η) and Zeta (ζ) Herculis, with two 7th-magnitude stars flanking it. Keen naked-eye observers may spot it under good dark skies, while binoculars will show a bright hazy glow. With larger-aperture telescopes and more magnification M13 becomes alive with stars that can be resolved right to the core, making this one of the most attractive globulars in the Northern Hemisphere sky. Look out for the dark 'propeller' feature, as well as several curves of stars that really bring it to life. ▸



8. Messier 92

Catalogue number: NGC 6341
Constellation: Hercules
Magnitude: +6.5
Minimum equipment: 6-inch reflector; 3-inch refractor

M92 gets overshadowed by its brighter, flashier neighbour, M13, but don't let that put you off. If it were anywhere else it would be a showpiece. To find it, take a line from Eta (η) to Iota (ι) Herculis and you will find this fuzzy blob awaiting discovery. It is a little more compact than M13 and, to some observers, a little extended in the north-south axis. Its fainter outer halo also has a slightly asymmetric shape.

9. Messier 56

Catalogue number: NGC 6779
Constellation: Lyra
Magnitude: +8.4
Minimum equipment: 8-inch reflector; 4-inch refractor

M56 is another of the less visited globulars, a result of its proximity to the Ring Nebula, M57, which lies nearby. M56 can be found on a line from Gamma (γ) Lyrae to Albireo, Beta (β) Cygni. It is a softly glowing haze that isn't very compact at all, yet the few brightish stars scattered across its disc add to its charm. Its shape is quite asymmetric and its core is not a particularly strong component, but there are hints of stellar streams racing away from the centre.

10. Messier 71

Catalogue number: NGC 6838
Constellation: Sagitta
Magnitude: +8.2
Minimum equipment: 8-inch reflector; 4-inch refractor

M71 is easy to find, midway between Delta (δ) and Gamma (γ) Sagittae. For several years it was debated whether it is a dense open cluster or loose globular cluster. The debate has been settled in favour of it being a globular, relatively close to us in space. Because of its looseness, there is no dense core apparent, but star trails and dark lines do seem evident. M71's overall shape resembles a 'Y'.

11. Great Sagittarius Cluster

Catalogue number: M22, NGC 6656
Constellation: Sagittarius
Magnitude: +5.2
Minimum equipment: 6-inch reflector; 3-inch refractor

Northeast of Lambda (λ) Sagittarii, this globular is the closest to Earth and the brightest on our list. Only the Southern Hemisphere's Omega Centauri and 47 Tucanae are brighter. If it was higher in the sky for Northern Hemisphere viewers, M22 might top our rankings. A glorious globe of stars that binoculars reveal as a nebula, it becomes starry in 6-inch scopes. Slightly oval with a faint outer halo, a dark lane through the core adds to its splendour.

12. Messier 28

Catalogue number: NGC 6626
Constellation: Sagittarius
Magnitude: +6.9
Minimum equipment: 8-inch reflector; 4-inch refractor

M28 is another of those underappreciated globulars that has been overshadowed by a nearby neighbour, in this case M22. It lies just northwest of Lambda (λ) Sagittarii, and so all three objects can be seen together in the same binocular view. M28 has a compact core with a faint halo and can appear slightly elongated. Indeed in his book *The Messier Album*, astronomer John Mallas describes it as "looking like a cucumber."

FRANZ KLAUSER/ MANFRED WASSHUBER/CCDGUIDE.COM, MICHAEL BREITE/STEFAN HEUTZ/WOLFGANG RIES/CCDGUIDE.COM, BERNHARD HUBL/CCDGUIDE.COM X 3, CEDIC TEAM/BERNHARD HUBL/CCDGUIDE.COM, DANIEL VERSCHATSE/CCDGUIDE.COM

13. Jellyfish Cluster

Catalogue number: M30, NGC 7099
Constellation: Capricornus
Magnitude: +7.2
Minimum equipment: 8-inch reflector; 4-inch refractor
The Jellyfish lies close to the star 41 Capricorni and on a line with Zeta (ζ) Capricorni. It is in a retrograde orbit about the inner halo of the Milky Way and is undergoing core collapse. Some indications suggest it was not formed in our Galaxy but may be captured from a satellite galaxy. It has a very compact core with a halo and needs moderate to large apertures to resolve its stars.

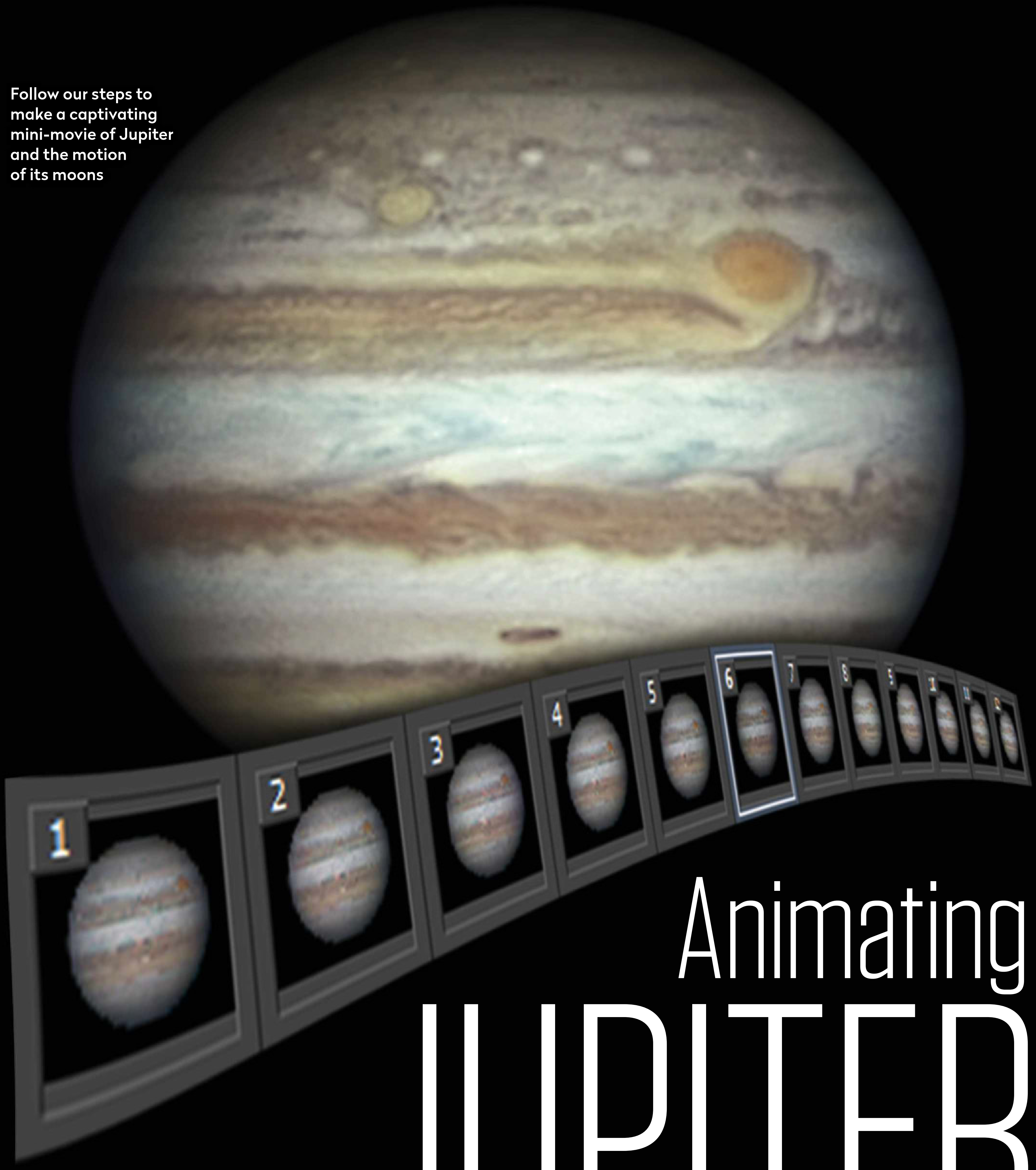
14. Messier 2

Catalogue number: NGC 7089
Constellation: Aquarius
Magnitude: +6.6
Minimum equipment: 6-inch reflector; 3-inch refractor
M2 lies almost a third of the way between Beta (β) Aquarii and Epsilon (ε) Pegasi and is easily visible in binoculars as a smudge of light. It appears dense with a fainter halo and a 10th-magnitude star to its northeast. An interesting feature of M2 is a dark lane or line curving through the outer part of the core to the northeast, which is visible to both visual observers and imagers. A regular watch of this globular cluster will reveal the varying brightness of a prominent RR Lyrae star, which fluctuates from mag. +12.5 to +14.0 over a period of 11 days. It is located on M2's eastern side, just north of the centre.

15. Great Pegasus Cluster

Catalogue number: M15, NGC 7078
Constellation: Pegasus
Magnitude: +6.3
Minimum equipment: 6-inch reflector; 3-inch refractor
M15 can be found as a fuzzy blob 4° to the northwest of Epsilon (ε) Pegasi and appears as an impressive smudge in binoculars. Larger-aperture scopes show it as quite dense and brightening rapidly towards the centre, with an uneven faint halo surrounding it. On the northeast edge of the core there is a dark patch and a further test of observing skills lies in resolving the faint, spidery 'arms' of stars that stretch out from the centre. M15 has over 100 variable stars, which are mainly RR Lyrae variables, and one faint planetary nebula, Pease 1, which is a challenge for large-aperture instruments.
See our Deep-Sky Tour on page 56 for more on M15 and Pease 1.

Follow our steps to make a captivating mini-movie of Jupiter and the motion of its moons



Animating JUPITER

Transform your images of the gas giant into an awe-inspiring animation of its swirling storms and marvellous moons. **Pete Lawrence** shows you how

ALL PICTURES: PETE LAWRENCE

As Jupiter begins to get higher in the sky as seen from the UK, its imaging potential continually improves. By photographing the planet with a high-frame-rate camera, it's possible to record the state of the gas giant's atmosphere. But you can also stitch together sequences of these images, creating animations showing how the planet rotates. These can be used to clarify atmospheric details as they turn with the planet, or reveal the orbital dance of the four bright Galilean moons. In this article we look at the techniques to make your own Jovian animations, from capture through to the final build.

▲ The altitude of Jupiter is an important factor in how clear a view you'll get, with lower altitudes generally giving the worst view

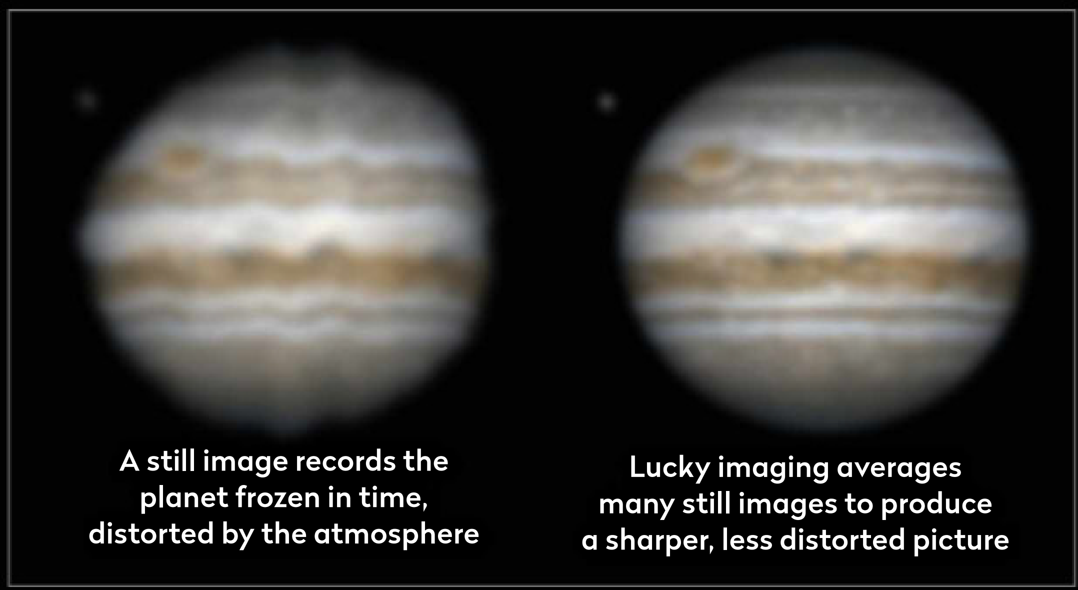
Capturing your images

A little planning will ensure you capture the best images to animate

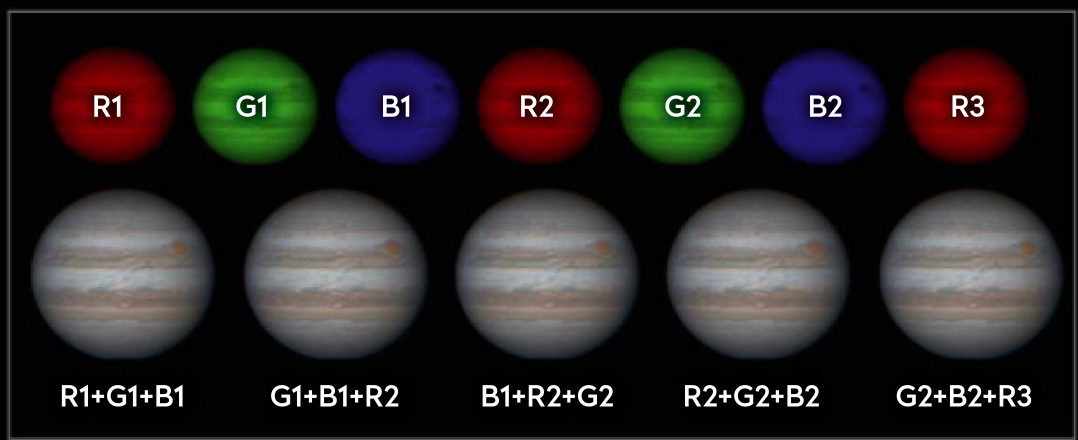
Jupiter is at its best when the atmosphere it's viewed through is stable. Atmospheric stability is affected by the weather, altitude of the object and the presence of the jetstream. You can determine when the most promising conditions are due from meteorological forecasts. Active fronts and deep low-pressure systems tend to cause instability, while high pressure tends to produce the most stable conditions. Weather dominated by high pressure with an absence of an overhead jetstream typically produces the best conditions, and websites such as Netweather provide jetstream forecasts for this: **www.netweather.tv/charts-and-data/jetstream**.

It is when Jupiter is positioned due south that it's highest in the sky and above the thickest, most turbulent part of the atmosphere. If you work out how long you want to image for, you can time your session so the planet is due south at the mid-point. Jupiter moves a fair bit over a long session, so make sure it won't disappear behind any foreground objects.

'Still imaging' – taking a single frame of a target – tends to produce poor results with planets. A stills camera, such as a DSLR, captures a snapshot, frozen in time, which is typically heavily distorted by the atmosphere. 'Lucky imaging' is a better solution: taking many images in quick succession, harvesting the best and combining them into a single image. Often resulting in thousands of images, the results are analysed and organised by quality, aligned and averaged to reduce noise. Known as registration-stacking, this laborious process is largely automated by freeware programs such as RegiStax (**www.astronomie.be/registax**) and AutoStakkert! (**www.autostakkert.com**). The final image these generate should be robust enough for post-capture tweaking.



▲ Lucky imaging requires effort, but the results are often significantly better



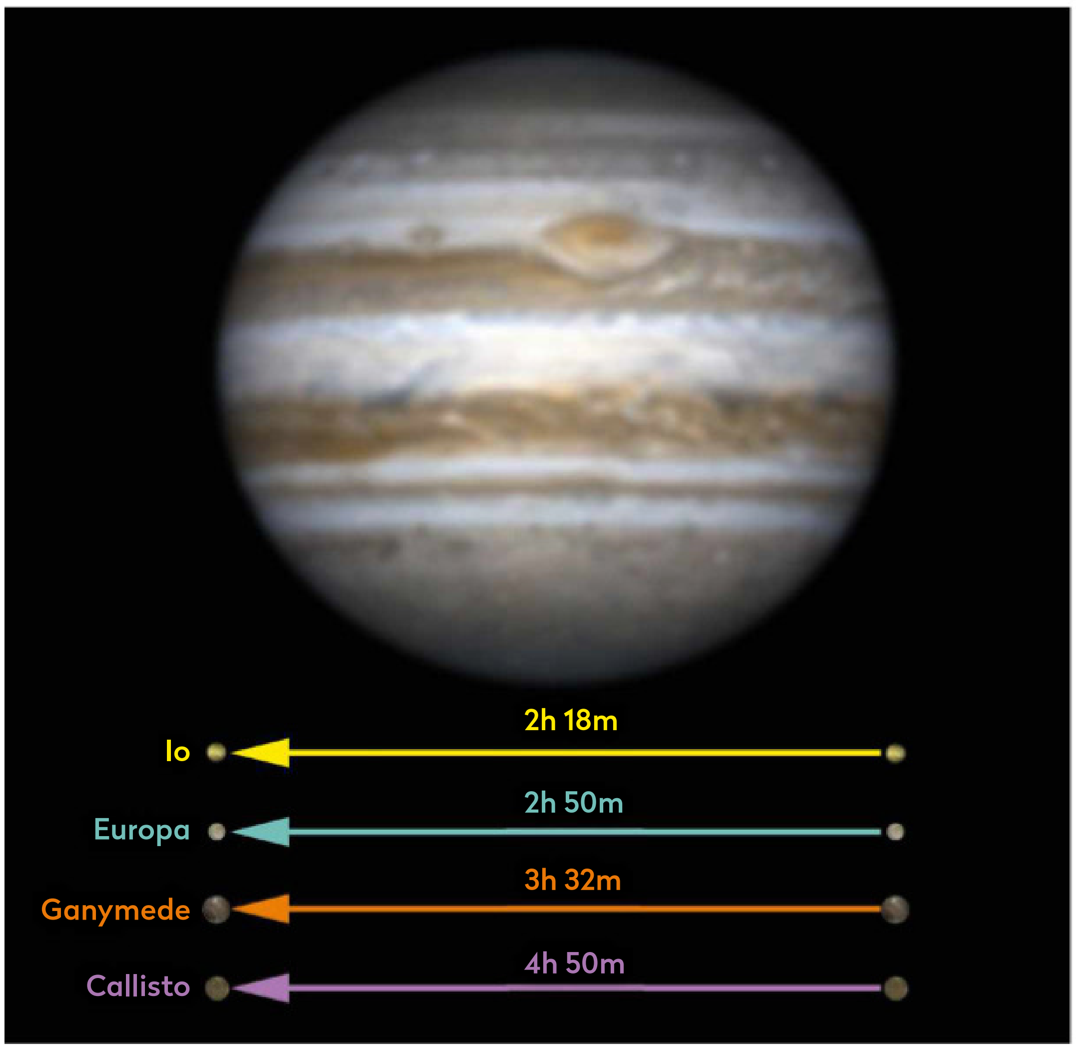
▲ Once one RGB set has been completed, each subsequent filtered capture can be used to complete a new full-colour image

Low-altitude bright targets suffer from chromatic dispersion, creating colour fringes around their north and south edges. With a colour camera, an atmospheric dispersion corrector can reduce this, and a filtered mono camera can diminish the problem too. Capturing individual red (R), green (G) and blue (B) frames is an excellent way to get high-quality results. Taking multiple filter sequences means you have a choice of frames to combine. For example, by taking two RGB sequences you can create an image with the RGB from the first set, but also an image with R from the second set, and G and B from the first, and so on. An infrared-sensitive camera with an IR-pass filter will produce high-contrast results that will animate well, and wavelengths at the red end of the spectrum tend to be less affected by atmospheric instability. ▸

Jupiter's four bright Galilean moons appear in a line, shining like stars near to the planet

Dance of the moons

The oscillating orbits of the Galilean moons make for an eye-catching video



▲ **How long it takes each Galilean moon to travel the apparent diameter of Jupiter, based on their orbits when closest to Earth. For the positions of each moon throughout this month,** **see our chart in the Sky Guide, page 49**

Jupiter's four largest, Galilean moons, Io, Europa, Ganymede and Callisto, are bright enough to be recorded with a conventional stills camera. With a large enough image scale, they can be shown clearly as separate entities to the planet and, over time, their movement around Jupiter can be recorded.

There are several ways to accomplish this. One is to ignore the planet's disc entirely and simply adjust the exposure so the moons record as bright points of light. It pays to maintain a reasonably short exposure time here: too long an exposure can produce issues such as each moon 'dot' 'wiggling' at high frequency, due to instabilities in our atmosphere. If the telescope's mount isn't accurately polar-aligned, extended exposures will also result in the moons appearing as short lines rather than points.

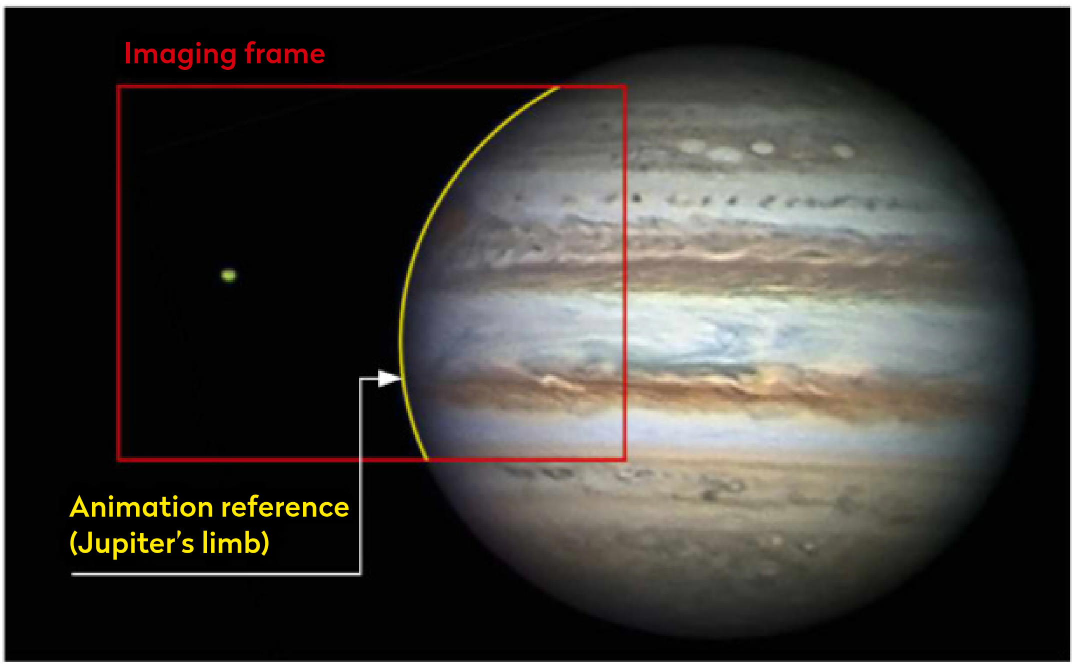
Lucky imaging can help overcome many of the vagaries introduced by our unstable atmosphere. If imaging simply to record a moon as a bright dot, you may still end up with a moon's image looking larger than it should, but it'll be tighter than it would be using a stills camera with a long exposure.

The Galilean moons orbit Jupiter at different periods according to their distance from the planet. Innermost Io takes 1.8 Earth days, Europa 3.6 days, Ganymede 7.2 days and Callisto 16.7 days. Consequently, the fastest movement across the sky will be shown by Io.

To create an animation sequence, determine how you want to image the moons: bright, or properly exposed. If you're just starting out, go for the bright option, adjusting your camera settings to record an over-exposed point of light. Then decide on the frequency of shots. If you're a novice, try to record a shot or frame sequence every 15 minutes, shortening the gap once you've become more accustomed to building animations. For high-frame-rate captures, try to keep your individual capture lengths to no more than 60 seconds.

You'll also need a point of reference for the final animation build, Jupiter being the obvious choice. If you intend to over-expose Jupiter, try to limit the over-exposure so you can still determine where the planet's edge is in each frame. This isn't an issue if you intend to capture the moon frames against a properly exposed planet.

As you get more comfortable creating moon animations, you can adjust the period between captures, or change the image scale to create interesting compositions.



▲ **In this extreme close-up example, Jupiter's edge will be the reference point for the final animation. Typically, the whole of Jupiter would be in frame**

ALL PICTURES: PETE LAWRENCE

A planet in motion

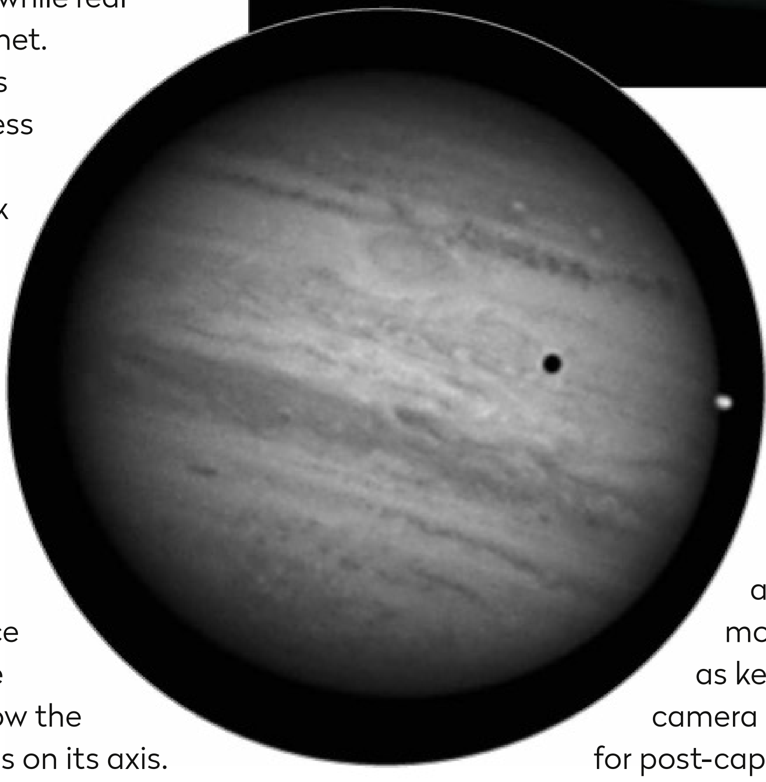
In video, the rapid spin and swirling air currents of Jupiter come dramatically to life

With good seeing, there's amazing detail to capture in the gas giant's constantly changing atmosphere

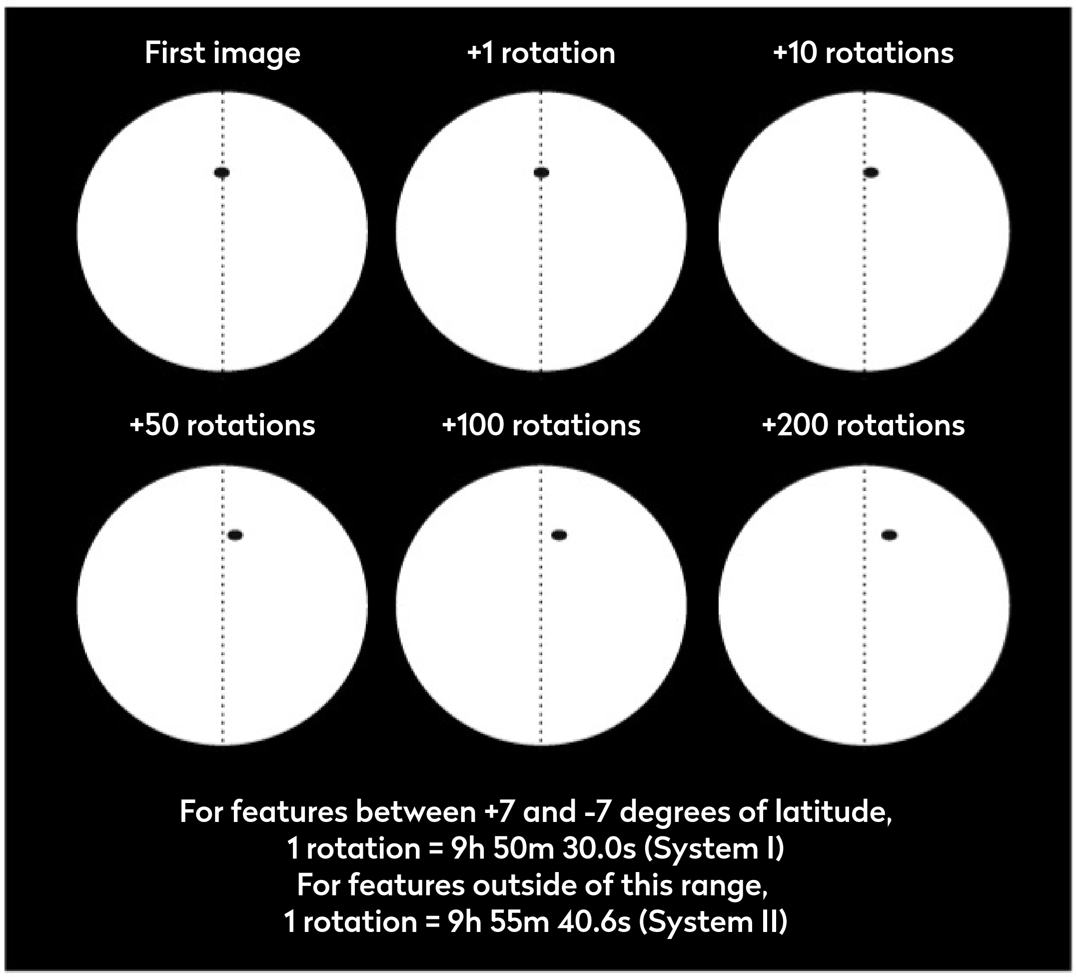
The banded atmosphere of Jupiter, full of ever-changing detail, is an amazing sight to observe and image with a medium to large aperture reflector of 6 inches (150mm) upwards. Some features, such as the Great Red Spot, are large and obvious to see, while others may be subtle, appearing like small areas of noise on single still images. This is where animation really comes into its own. In an animated sequence, disc noise disappears between frames, while real features persist and rotate with the planet.

There is some motion within Jupiter's atmosphere, but this is hard to see unless you're using special techniques. For example, with careful planning and luck with the weather, it should be possible to take an image of Jupiter at the same longitude over many rotations. Animating these will then reveal atmospheric features drifting and developing over time.

Typically Jovian animations are done with frames recorded at regular intervals over an extended time of many minutes or hours. These sequence animations use the planet's limb as the anchor reference, the result showing how the features come and go as Jupiter rotates on its axis.



◄ **Transiting moons and their shadows make great animation subjects. Here Io shines bright through an infrared-pass filter, the moon clearly standing out against Jupiter's disc**



▲ **By animating frames taken a specific number of rotations apart, you can reveal the movement of features such as cloud bands, spots and storms in Jupiter's atmosphere, and show how they change and evolve over time**

With each rotation taking less than 10 hours, the results can be quite spectacular.

To capture images for an animation, a polar-aligned tracking equatorial mount is highly recommended. As well as keeping the planet in position on the camera sensor chip, this removes the need for post-capture orientation adjustment, as each image will have the same orientation.

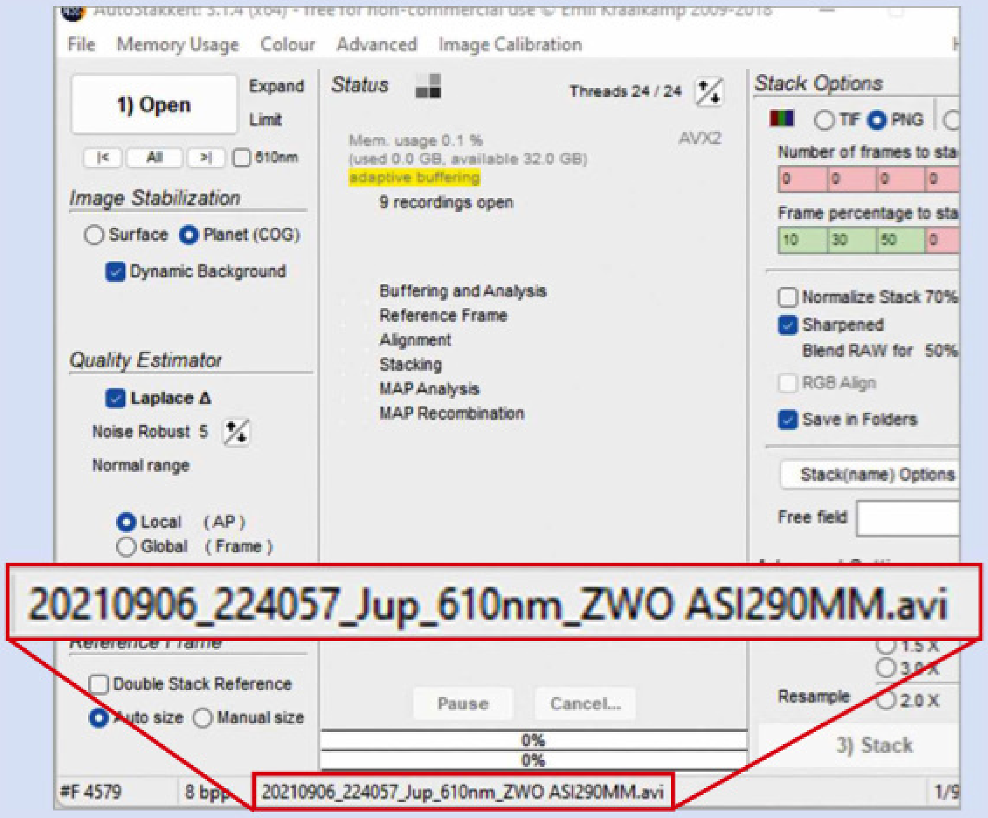
As was the case with the moon animation, carefully consider what the capture frequency should be. Bear in mind high-frame-rate captures typically require 30 to 60 seconds to record. A sequence of, for example, 50 seconds capturing the frames, then waiting 10 seconds, followed by another 50 seconds of capture and 10 seconds of waiting, will produce a very smooth animation but will also be labour-intensive.

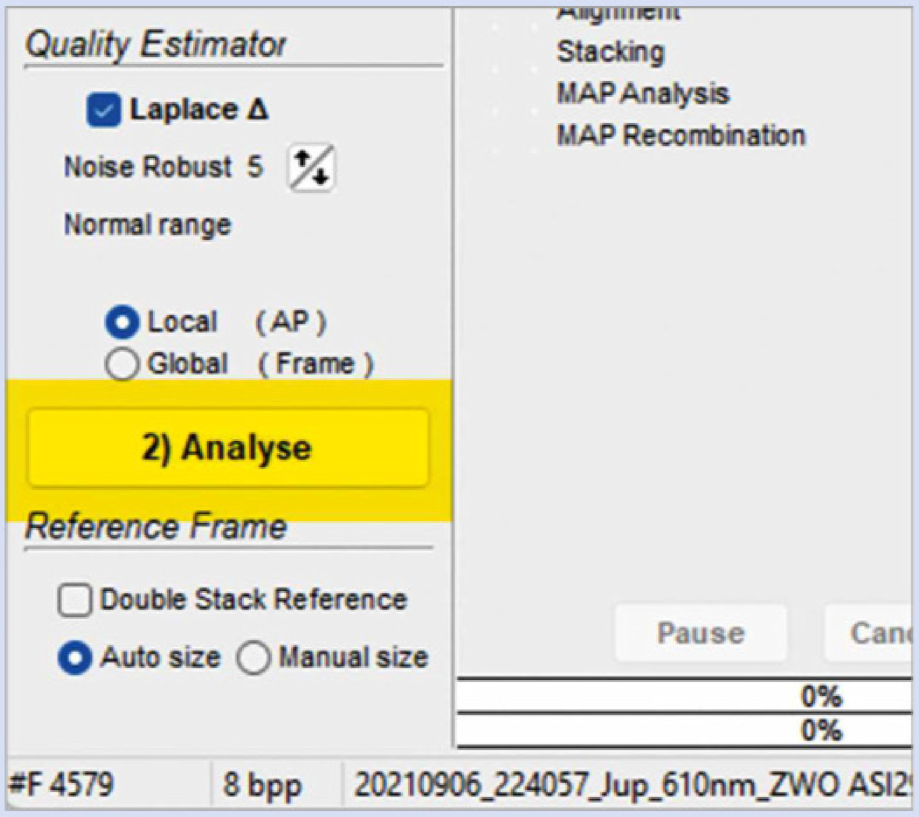
Longer intervals between captures take the pressure off, but the final animation won't be as smooth. Longer gaps also have the advantage of less data to handle and less post-capture processing to do. It's your choice, but we'd recommend looking at a starting figure of 10 minutes between frames.

The shadows cast by transiting moons make for particularly striking animations, providing good motion and image contrast with the steadily rotating Jovian globe. Moons involved in other events make excellent targets too. For example, consider animating a moon moving behind (occultation disappearance) or being revealed by (occultation reappearance) Jupiter's globe. Alternatively, a moon being hidden (eclipse disappearance) or revealed (eclipse reappearance) by Jupiter's shadow can make for a dramatic sight through larger apertures. ►

Building the animation

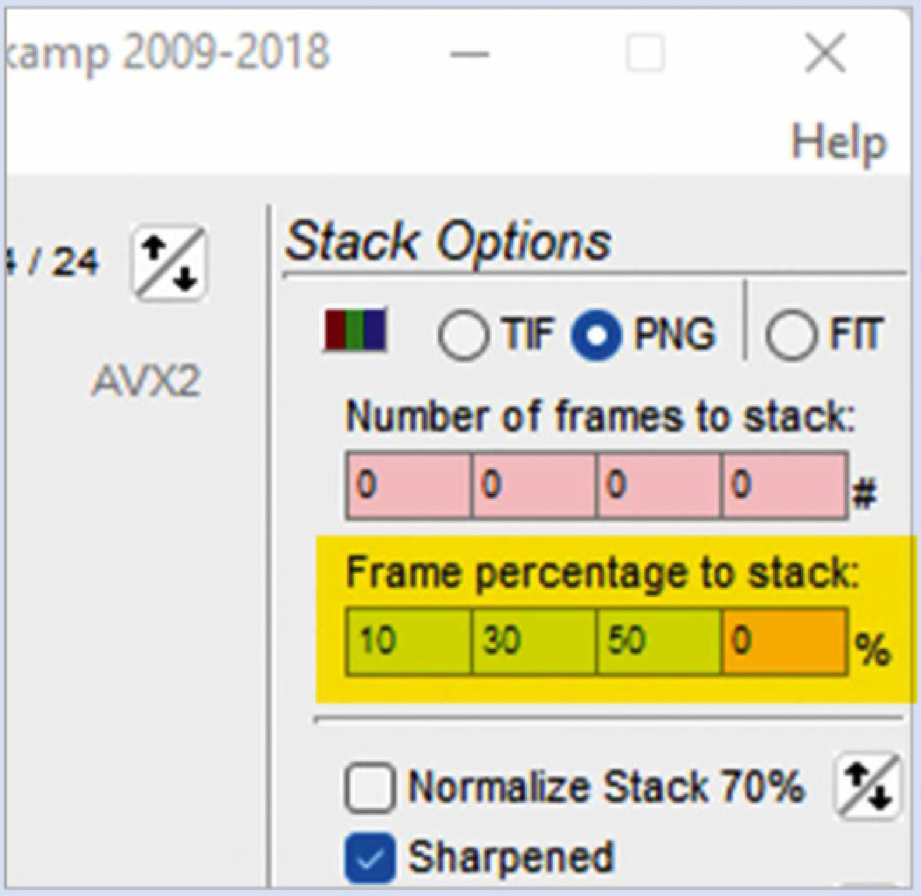
Free software and a little experimentation are all you need to create your animation

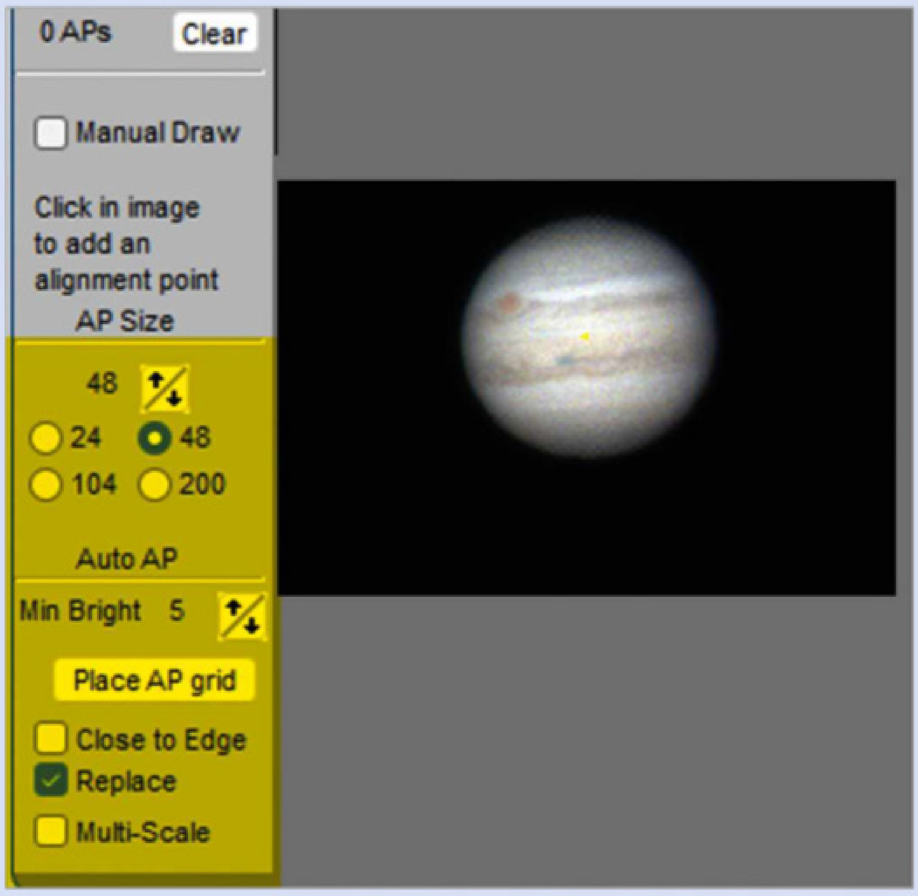




Step 1
Once you have a set of high-frame-rate capture sequences, it's recommended to make sure that their file names have the date and time within them. If not, consider prefixing them with the correct date and time in the format 'YYYYMMDD_hhmmss'. Once ready, drag them into AutoStakkert! for processing.

Step 2
You'll need to set the processing steps for the first image, and then subsequent images will be processed the same way. AutoStakkert!'s interface may look a bit daunting, but the basic method of use is quite straightforward. Once you've dragged in your frames, click 'Analyse' and let the program run.

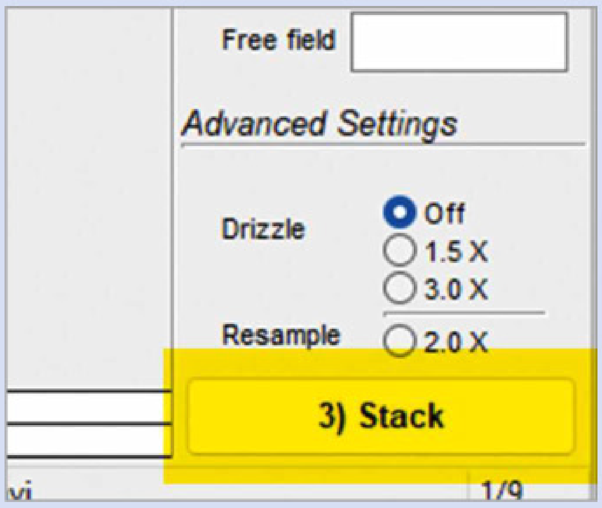


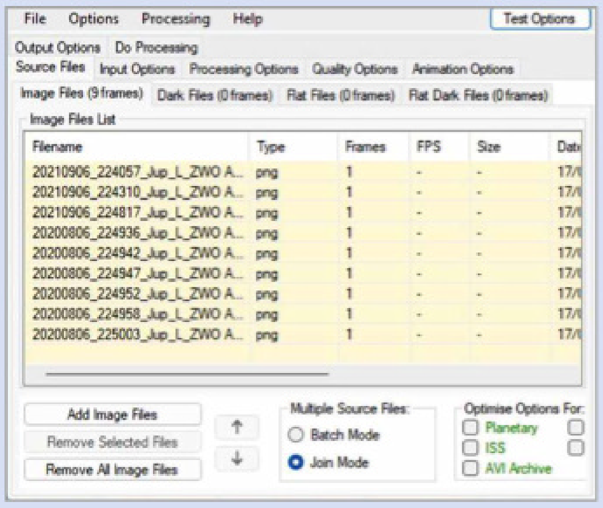


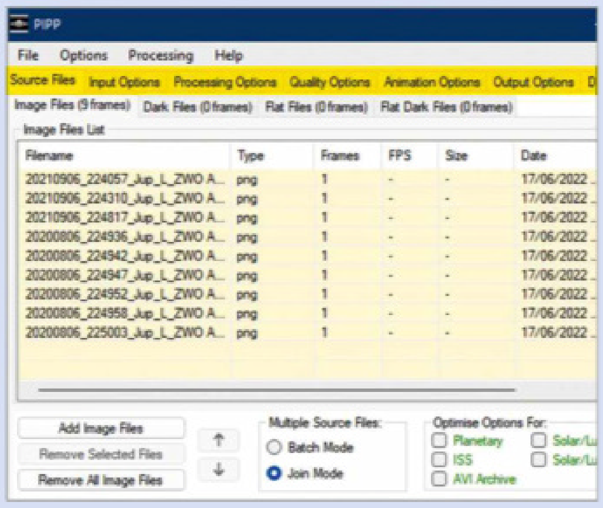
Step 3
Once done, under 'Stack options' set one of the 'Frame percentage to stack' values to 30. This means that 30 per cent of the input frames will be used. You can experiment with other values as you please. There are four settings that can be loaded and a further four for the specific number of frames to be used.

Step 4
In the 'Frame View' window, select an appropriate alignment point size (try 48 if you're not sure), click 'Place AP grid', ensuring that the ensuing set of alignment point markers select only the planet. If not, you may have to adjust the 'Min bright' value and re-click 'Place AP grid'.

ALL PICTURES: PETE LAWRENCE



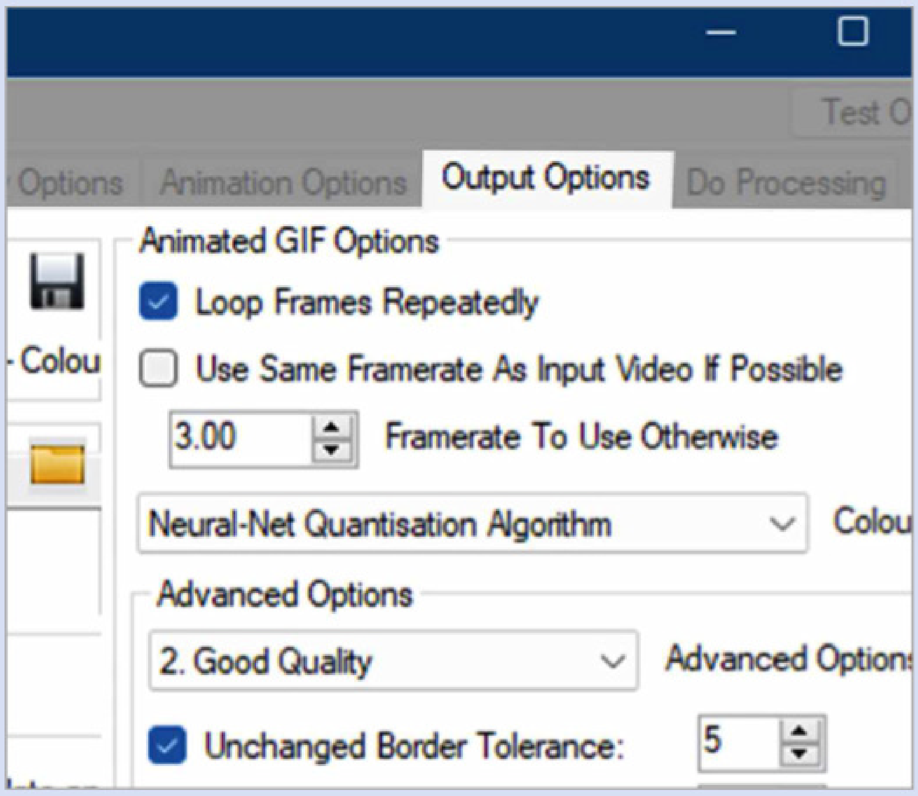


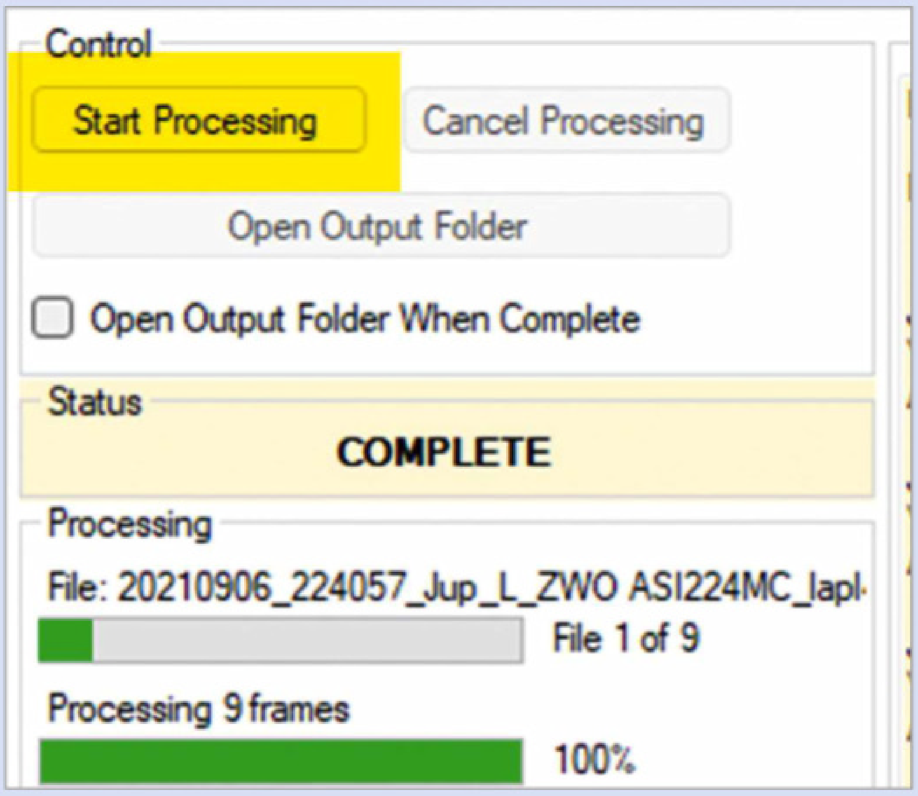


Step 5
Once done, press 'Stack' in the main program window. Let the program process all of the sequence files. If you choose to tweak the results, for example sharpening them using RegiStax, make sure you apply the same processes to each one.

Step 6
Using the freeware PIPP application (**sites.google.com/site/astropipp**), drag the still frames generated by AutoStakkert! into the main PIPP window. A dialogue will normally appear stating that 'Join mode' has been activated. Click 'Okay'.

Step 7
PIPP has many options that can be set and it's left to you to experiment with those not mentioned here. The base images are left untouched, and the worst it will do is fill up your hard drive, so feel free to experiment.





Step 8
Select the 'Animation options' tab, then 'Play all frames in forward order'. Under 'Output options', select the desired output format, eg animated GIF. Select the output folder. Select 'Loop frames repeatedly' and set an appropriate frame rate. If you get this wrong, just choose a different value and re-process.

Step 9
Finally, select the 'Do processing' tab and click 'Start processing'. Your output file will be created and stored in the selected output folder. It's that simple. If it's not right, adjust the appropriate setting within PIPP and re-process. By just tweaking the settings you can make a huge difference to your end result.

Creating an animation of Jupiter isn't that much harder than generating a single image, it's just more processing-intensive, requiring steps that you'll need to repeat several times. Once you've built your first animation, the results will hopefully encourage you to have another go.

Don't be afraid to experiment, perhaps refining your technique to produce a smoother result. With Jupiter now climbing higher in UK skies and approaching its best appearance for the year, this is a great time to start producing your own Jovian movies.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Mae Jemison

Ezzy Pearson celebrates the 30th anniversary of the first Black woman flying in space


An accomplished engineer and doctor, Jemison flew aboard Space Shuttle Endeavour in September 1992

NASA X 4, EVERETT COLLECTION INC/ALAMY STOCK PHOTO

When Mae Jemison was 12 years old, she watched enraptured as Neil Armstrong took his first steps across the surface of the Moon during the Apollo landing. But there was one thing that upset her: none of the people being sent into space looked like her. Later in life, she would be the one to change that. Thirty years ago this month, on 12 September 1992, Jemison became the first Black woman to fly in space.

"As a little girl growing up on the south side of Chicago in the '60s I always knew I was going to be in space," Jemison said in a 2013 speech at Duke University.

There was, however, one Black female space-farer Jemison could turn to as a role model in her youth, albeit a fictional one: *Star Trek*'s Lieutenant Nyota Uhura, played by Nichelle Nichols. Encouraged by her example, Jemison pursued the sciences, eventually attaining her medical degree in 1981.

During her early career, Jemison served as a general practitioner, conducted relief work throughout Africa with the Peace Corps, helped research vaccines with the Centre for Disease Control and, somehow, also found time to learn Russian, Japanese and Swahili. Then in 1985, Sally Ride became the first American woman to fly in space, rekindling Jemison's long-held dreams.

"I picked up the phone. I called down to Johnson Space Center. I said 'I would like to be an astronaut'. They didn't laugh! I turned in the application," Jemison told the website The Mary Sue in 2018.

In 1987, 2,000 people applied to join NASA's Astronaut Group 12. Fifteen were accepted, including Jemison. After completing her training, in 1989 she was assigned to STS-47, a joint mission with the Japanese space agency on which she would conduct a myriad of materials and life science experiments alongside her fellow astronauts.

A dream realised

After a three-year wait, Jemison finally achieved her dream on 12 September 1992 when the Space Shuttle Endeavour blasted off on mission STS-47. She spent eight days in space, orbiting Earth 127 times. As a nod to the woman who inspired her, Jemison would open communications every shift by repeating Uhura's signature phrase, "Hailing frequencies open".

Keen to represent people who hadn't been seen in space before, she brought several artefacts with her including a statue from the women's society of Bundu

Nichelle Nichols and NASA

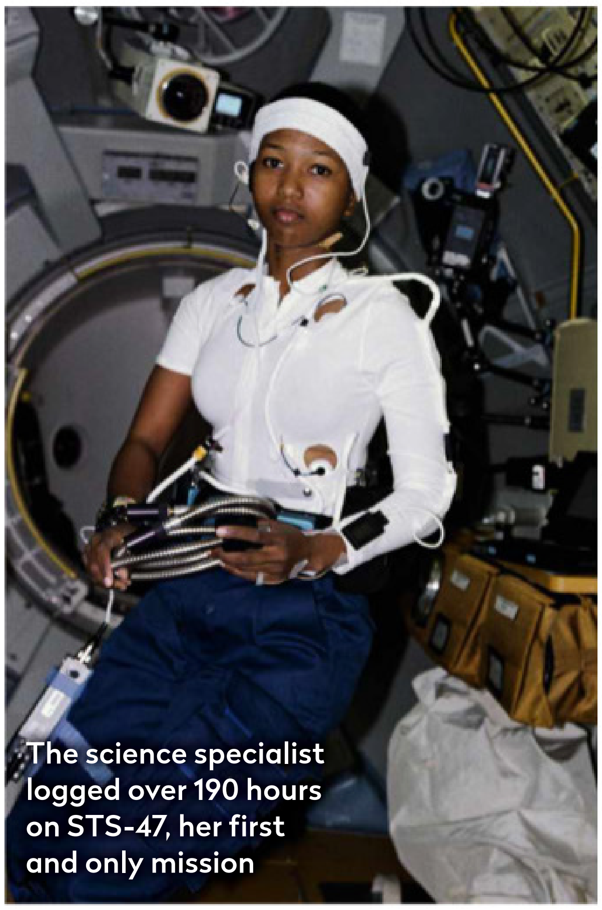
The actress helped convince the world that everyone had a place at NASA


NASA's 1977 recruitment film featuring the *Star Trek* star

In 1977, NASA reopened astronaut training for the first time since 1969, to find the dozens of crew members needed for the upcoming Space Shuttle programme. But there was one problem: despite now accepting applications from women and from people of colour, the years of being shut out of NASA were discouraging them from applying.

With a few months left before applications closed, NASA joined forces with the most famous Black female astronaut of the day: *Star Trek*'s Lieutenant Uhura herself, Nichelle Nichols. The actress was well aware of her place as a role model, having been told by Martin Luther King Jr about its importance. She had already begun advocating for more diversity in the space sector, but by joining forces with NASA she was able to conduct a campaign tour across the US, convincing potential astronauts that not only did the agency now accept people of colour and women, but that they were also a welcome and needed part of space exploration.

The initiative paid off. NASA's 35-member astronaut class of 1978 contained the first female astronaut (Sally Ride), the first African American astronaut (Guion Bluford) and the first Asian American astronaut (Ellison Onizuka). Nichols continued to help recruit new astronauts into the late 1980s and has been credited as an inspiration by dozens of astronauts, scientists and administrators, including Mae Jemison.


The science specialist logged over 190 hours on STS-47, her first and only mission

in West Africa and a pennant from the first African American sorority, Alpha Kappa Alpha.

She returned to Earth on 20 September, completing what would be her only flight. In 1993 she left NASA but continued to advocate for science education, particularly among minority students. Since then she has founded the Jemison Group Inc, which investigates the social and cultural impacts of technological advancements, and the Dorothy Jemison Foundation for Excellence (named after her mother) which helps children to develop 'personal excellence', as well as taking professorships at Dartmouth College and Cornell University.


Appearing on *Star Trek*, the show that inspired her, shortly after her return

Jemison's space journey came full circle in 1993 when LeVar Burton, the actor who played Geordi La Forge on *Star Trek: The Next Generation*, discovered that Jemison was a fan of the show and invited her to appear. She played Lieutenant Palmer in a cameo appearance in the episode Second Chances, the first real astronaut to appear on the show.

Two decades later, in 2012, she took on the task of ensuring the future portrayed on *Star Trek* becomes a reality, when her foundation was awarded the 100 Year Starship project, an initiative to push forward the progress of human spaceflight to another star within the next 100 years.

"We need to make sure we're using the full wealth of human talent: across ethnicity, across gender, across geography, across disciplines," Jemison said to PBS's *Nova* programme in 2015.


▲ In Spacelab-J, where her research ranged from frog fertility to motion sickness

"All the capabilities that are needed for a successful journey to another star system by humans, are all the capabilities that we need to sustain ourselves as humans on this planet. And so we believe pursuing an extraordinary tomorrow creates a better world today."

How to build a sunbed binocular mount

Enjoy comfy, hands-free viewing with this attachment for your garden lounger

With your DIY mount taking the strain, you're free to make notes or sketch your target

With this mount to hold a pair of binoculars to your sunbed, you'll be able to relax your arms while looking at the sky and keep your target steady in the field of view. The design allows you to angle the binoculars up and down and side to side, and because it's mounted on the lounger it doesn't take up space on the ground. You can sit side by side with someone else too.

The parallelogram mechanism means binoculars can be brought close to the eyes of both taller and shorter observers. You can even swap places while retaining your aim towards the target area of sky.

The simple mounting 'beam' on which the mechanism is fixed can be modified to suit a variety of loungers. We added three short wooden pieces to ours. One has a nylon screw which presses against the back of our lounger to steady everything. By adding short lengths of wood in the right place it should be possible for the beam to be steadied against the frame of any design of lounger. For extra security and peace of mind, you may wish to use a clamp or bungees to fix the beam on tight.

We chose softwood strips to make our mechanism. Once you have used the downloadable plan to mark out the lengths and hole positions, it's a simple task to cut and drill them. To maintain accuracy, we taped bundles of similar parts together before drilling so they came out identical. We rounded off the ends with a sanding machine for aesthetic reasons, but it is important to get the wooden elements smooth so they move freely. The length of the parts was worked out by trial and error and should apply to most situations. If your lounger differs greatly, however, you might need to adjust the length of the two arms which form the rear parallelogram (make them longer and drill several sets of holes to experiment with, then trim to length once you are happy).

There are washers between all the wooden strips and the nuts, which pivot on the threaded rod. We used Nylock locking nuts when making the final assembly as these can be tightened to give just the right amount of friction. You need your mechanism to move smoothly but stay in position once set. To overcome some of the weight of the binoculars, we made up some elastic straps, which stretch between hooks that are screwed into the wooden parts. In use, we found the mount worked perfectly once adjusted.

Observing without having to hold up even relatively light binoculars transformed our experience of a summer night's observing session. You can even make notes or sketches with your free hands – or sip a glass of wine!

Mark Parrish is a bespoke designer based in West Sussex

MORE **ONLINE**

Download a plan and additional photos to help with your build. See page 5 for instructions

What you'll need

- Tools: ruler, compasses, pencil, small wood saw, junior hacksaw, drill and drill bits.
- Timber: thin softwood strips of approximately 2,000mm total length x 25mm wide x 15mm thick. Thicker softwood strip for the mounting beam: 600mm long x 48mm x 18mm.
- Two small strips of stiff metal approximately 125mm x 25mm x 3mm. About 600mm of M6 threaded rod. M6 Nylock nuts and washers.
- A standard pair of binoculars (with a tripod screw fitting), 4 cup hooks, 0.5m of shock cord (elastic). Spray lacquer or varnish.

ALL PICTURES: MARK PARRISH

Step by step

Step 1

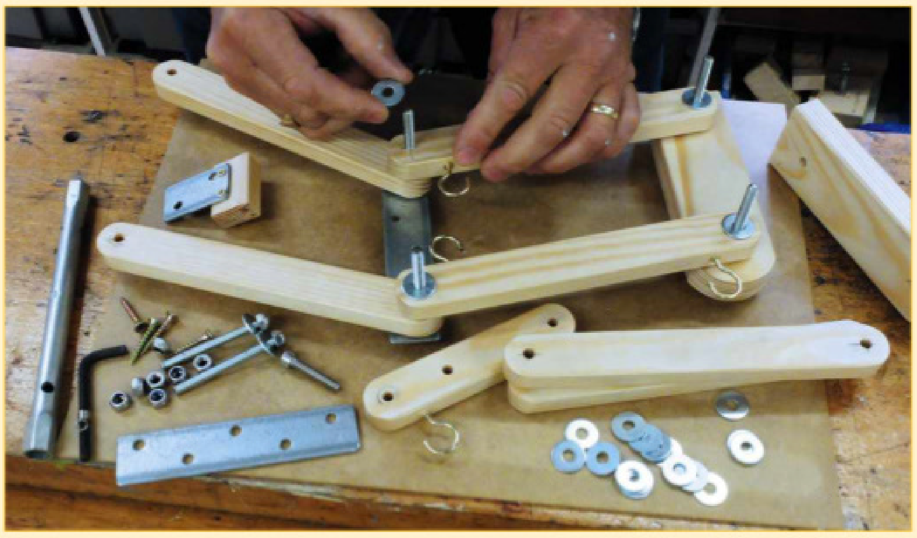
After marking out and cutting, you need to accurately drill the 6mm holes. Taping parts and drilling together ensures they come out identical (but only if your drill is held vertically). The length of the wood is less important than getting identical hole spacing.

Step 2

It is important to get the wood smooth. We used a plane to achieve this, but sandpaper is a good method as well. This is to help the pivots work freely. You now need to cut your threaded rods and make a metal bracket for the binoculars.

Step 3

A little experimentation is needed to fit the mounting beam to the lounger. We cut a 600mm strip of wood, and screwed/glued three smaller strips on it: two on the front, one on the back. You may need to modify this part of the design for your lounger.

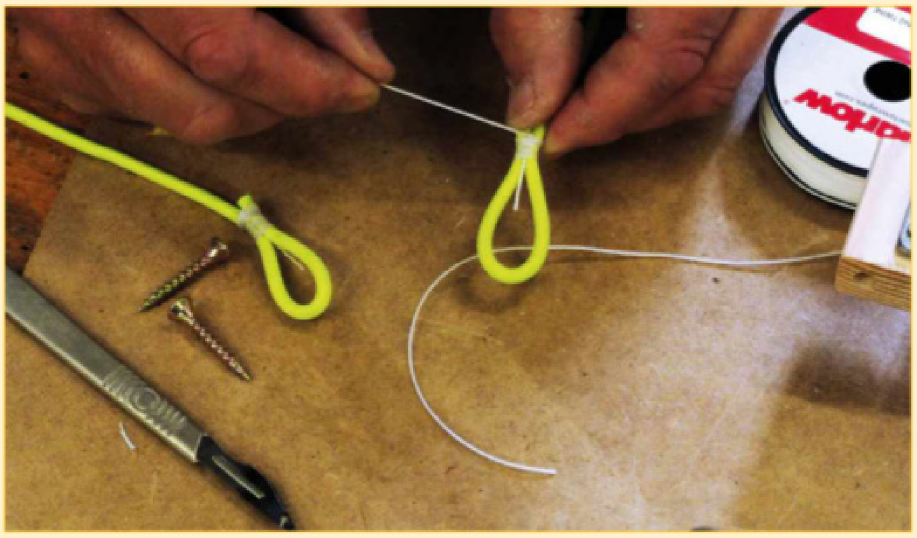


Step 4

Carefully assemble the parts. We used normal nuts (not locking ones). Your binoculars should have a tripod mounting screw hole (usually under a cap) to which you can fix the metal bracket. Mount the assembly to the lounger and check.

Step 5

We disassembled at this stage and sprayed the wood with clear lacquer. This provides some protection and helps it to pivot. You may wish to paint yours. Reassemble when dry, including some glue/screws between mechanism uprights and mounting beam.



Step 6

To help resist some of the weight of the binoculars, we added elastic straps. We knotted these for the prototype, but once we got the lengths right, we made some loops with whipping twine. These fitted to cup hooks screwed into the wood.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

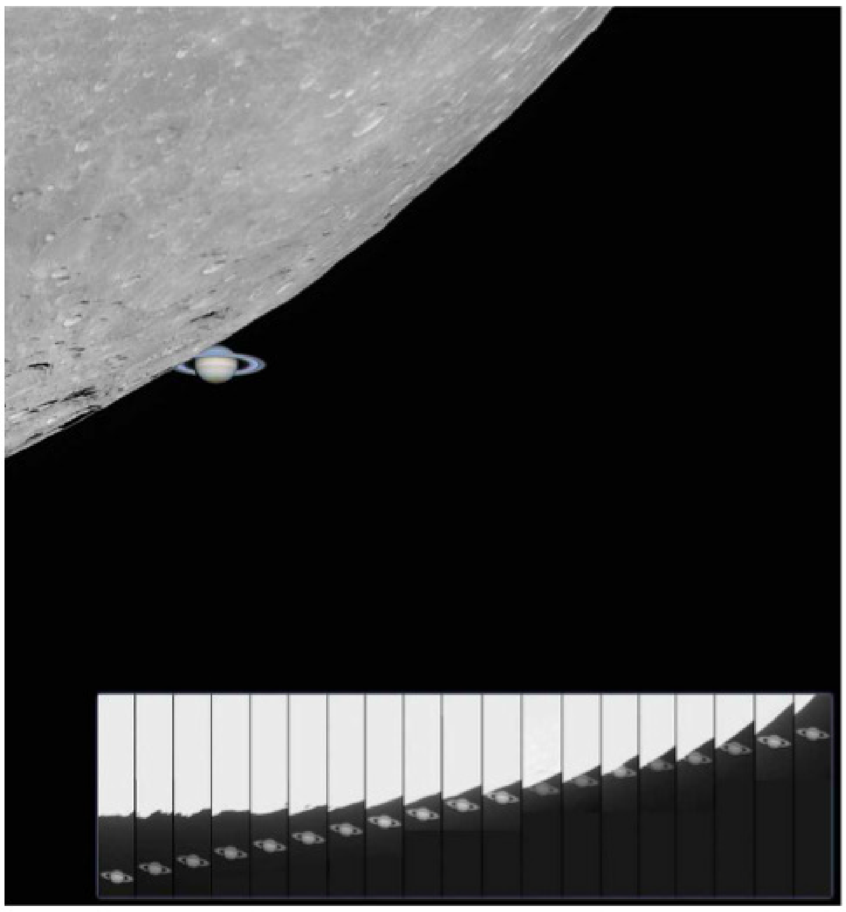
Lunar occultations of planets

How to image a far-from-easy Uranus disappearing behind the Moon on 14 September

Occultations of the planets by the Moon aren't very common and when they happen, all fingers are crossed for clear skies. If the weather holds good for the lunar occultation of Uranus on 14 September, there will be a lot of interest in the little planet, certainly more than it normally gets.

Unlike the main planets closer to the Sun, Uranus appears dim, right on the threshold of naked-eye visibility. It's also rather distant and looks small even through a sizable telescope. This presents issues with visually observing the event as well as some awkward problems when trying to image it.

These will be exacerbated by the fact that the start of the occultation will involve the Moon's bright limb passing in front of the planet. Setting up captures for Uranus will certainly over-expose the Moon, while exposing for the lunar surface may mean Uranus is lost from the shot altogether.



▲ **Choose how to showcase your results. This Saturn shot highlights the brightness difference between the planet and the Moon**

Fix upon framing

There are various imaging setups that can be used for this. First consider how you want to record the view: a wide field to cover the whole Moon or a riskier narrow field zoomed in on the planet? The latter isn't that hard to organise for the disappearance event, but adds uncertainty in when Uranus reappears from behind the Moon's dark limb: here you'll need your best guess as to where the planet will reappear.

Then there is the choice of whether to produce an image that is visually and scientifically accurate, or one that is an enhanced version of reality. The latter is perfectly acceptable as long as you state what you have done and the steps that led to the final image. Better still, consider combining both techniques to show the scientific aspects together with an enhanced version to better show what's happening.

This will entail performing the best capture of Uranus you can manage before the occultation, along with a separate capture optimised for the lunar surface. Ideally these should be taken around 30 minutes before or after the occultation. Or, to play it safe, both before *and* after the occultation – just to be sure!

During the event, the emphasis should be on exposing for Uranus: disregard the appearance of the lunar surface, which will almost certainly be over-exposed. The purpose of this capture will be to provide accurate positional information for the event. If possible, when the planet and Moon are in the same shot, make a note of the settings for Uranus and reduce the exposure to take a quick image of the Moon. This will help you figure out just where Uranus is in respect to the features on the lunar surface.

With a capture like this, practice makes perfect. If you get clear weather on any of the nights in the run up to the occultation, use them to practise imaging Uranus and the Moon so that on the night you'll know exactly what to do. But if something does go wrong, remember there's a similar event due to occur in the early evening of 5 December.

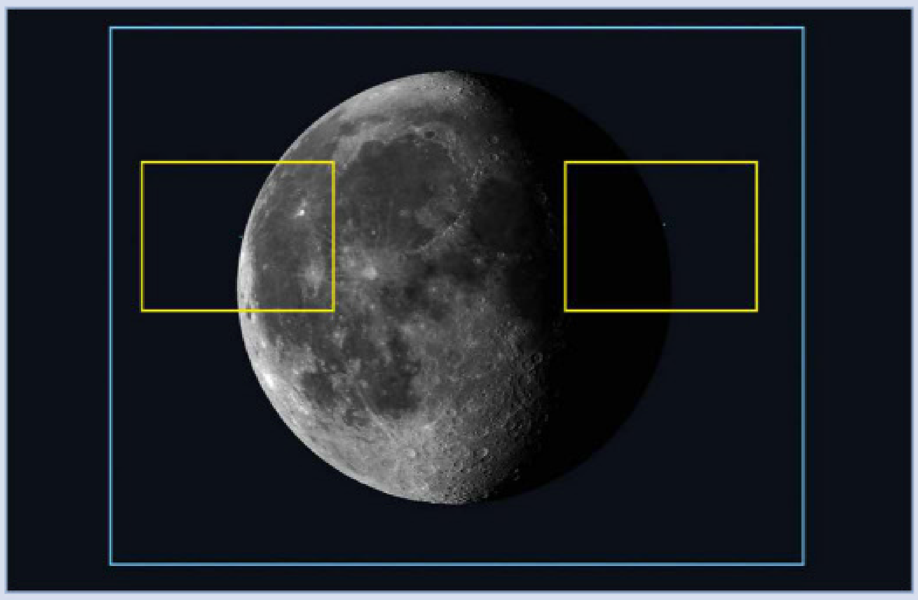
Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

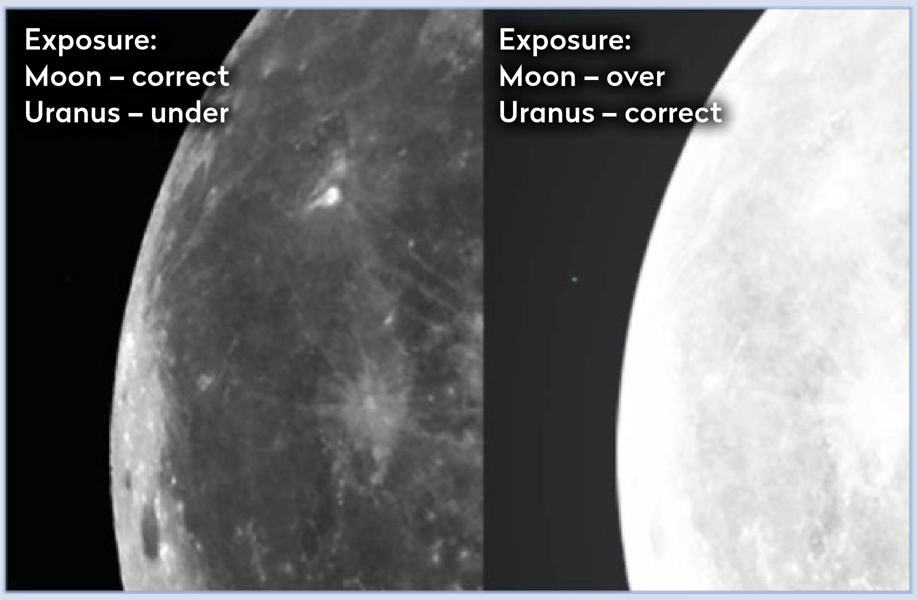
Equipment: camera, telescope, polar-aligned equatorial tracking mount

Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step



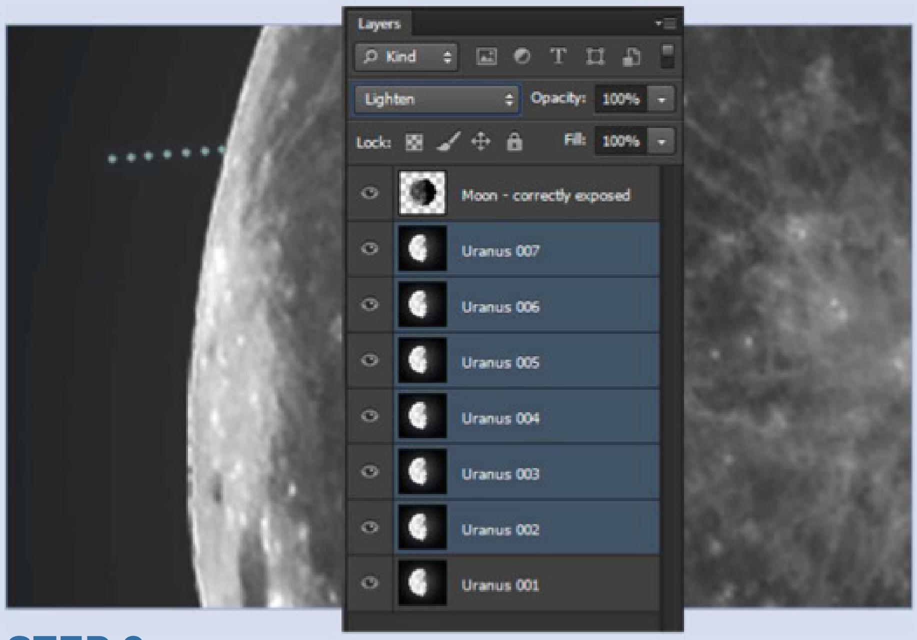


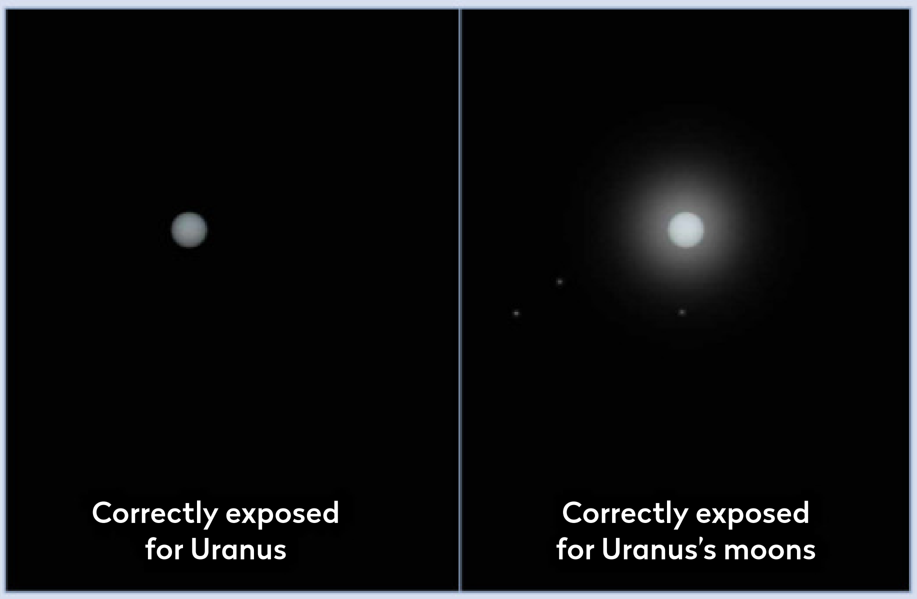
STEP 1

Decide how to image the event. A wide field can show the whole Moon but Uranus, at 3.7 arcseconds across, will look like a star. Its disc will appear 1/500th the apparent size of the Moon's 1,834-arcsecond disc. A close-up shot that allows you to capture Uranus as a disc will only fit a small portion of the Moon.

STEP 2

Consider capturing the Moon correctly exposed in one shot. Then, increase exposure so that Uranus shows, preferably with a well-defined edge of the Moon. Note the camera settings. Take shots at regular intervals to show the relative position of Uranus next to the Moon both before and after the occultation.



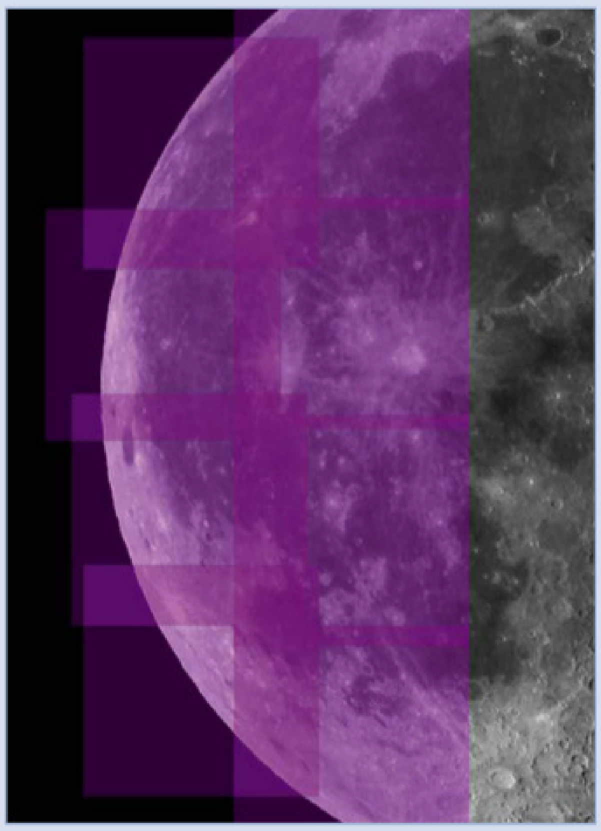


STEP 3

Load the over-exposed Moon shots into layers in a layer-based photo editor. Align them on the Moon's edge. Set all but the bottom layer's blend modes to lighten so Uranus shines through. Flatten, then add the correctly exposed Moon as a new layer, aligned on the bottom layer. Delete the sky around the correctly exposed Moon.

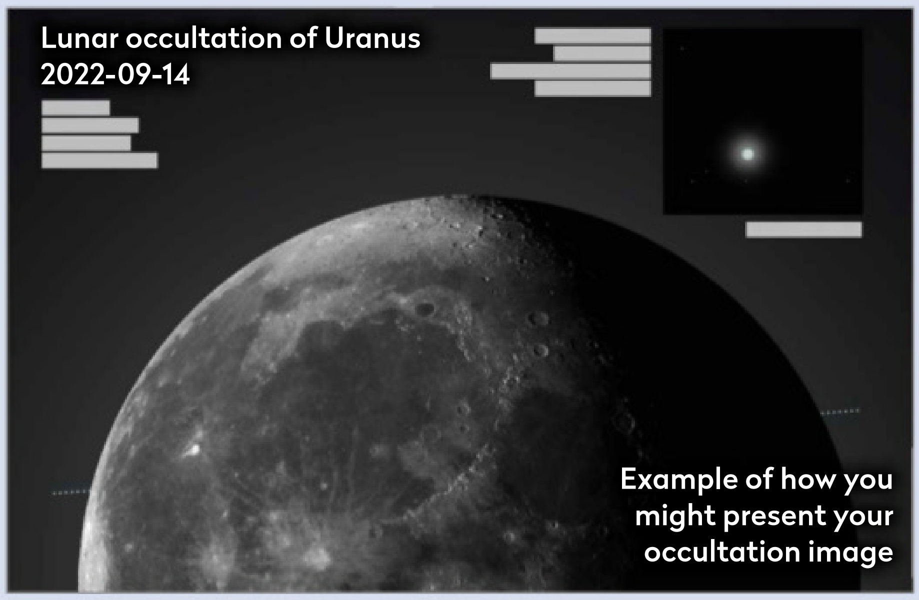
STEP 4

If you can make high-frame-rate captures at a large image scale, consider a multi-frame capture of Uranus before the occultation. With a mono camera, an IR-pass or long-pass filter (eg 610nm) may give a steadier result. Once the planet has been captured, consider increasing the exposure to try for Uranus's moons.



STEP 5

For large image scale setups, consider doing an extended lunar mosaic of the limb region where Uranus will disappear. If time is short before the occultation, this can be done while Uranus is hidden or after. If it's done before, simply follow the mosaic capture with correctly exposed shots of Uranus at regular intervals to record its position, as described in step 2.



STEP 6

For the reappearance, reset the camera to the correct settings for Uranus (see step 2). If you have an equatorial tracking mount, stay centred on Uranus from disappearance until reappearance. When done, compose the positional shots (see step 3), adding enhanced images of the Moon and Uranus as you have them.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

APY Masterclass

Cracking a smiley face in space

The processing routines that created the galactic grin of NGC 1055

Astronomy Photographer of the Year

Advice from a highly commended entrant in 2021's awards

Martin Pugh has previously won APY awards in 2009 and 2012. Retired from the Navy, he runs his own remote astro-imaging business from his home in rural Australia

▲ **A Smiley in Space, the final processed image that won Martin the APY nod**

Unlike big and bold face-on spiral galaxies such as M101, the Pinwheel Galaxy and M33, the Triangulum Galaxy, NGC 1055 is an edge-on spiral galaxy. Located in the constellation Cetus, the Whale, at a distance of approximately 52 million lightyears, its proximity to two bright stars lends itself to the nickname of 'a smiley in space'.

Described as a galaxy that has a prominent nuclear bulge crossed by a wide, knotty, dark lane of dust and gas, the immediate goal was to collect data in terms of both quality and quantity to be able to reveal these features in detail. Furthermore, a substantial quantity of data will largely suppress 'noise' when the data is combined, and this allows you to push the data further when processing.

I collected more than the 22 hours of RGB and luminance data that went into the final image, but those frames that did not pass my quality threshold were discarded. I have learned that including images with 'fat' stars has a direct impact on the quality of the final image. Luminance data is key. It is from this data that the eye perceives detail, so this was acquired when the galaxy was at its highest in the night sky and only the very best frames were used to resolve the knotty, dark lane of dust and gas.

Boosting the bulge

My processing goals using Photoshop were to enhance the nuclear bulge and overall colour of the galaxy and stars. Figure 1 (next page) is the result of combining the master RGB frames. Colour is looking good, but is somewhat underwhelming and in need of further enhancement.

I duplicated the background to form a new layer then applied the 'Match Colour' filter and set the

ALL PICTURES: MARTIN PUGH

Figure 1: Initially, the combined RGB frames were a little lacklustre

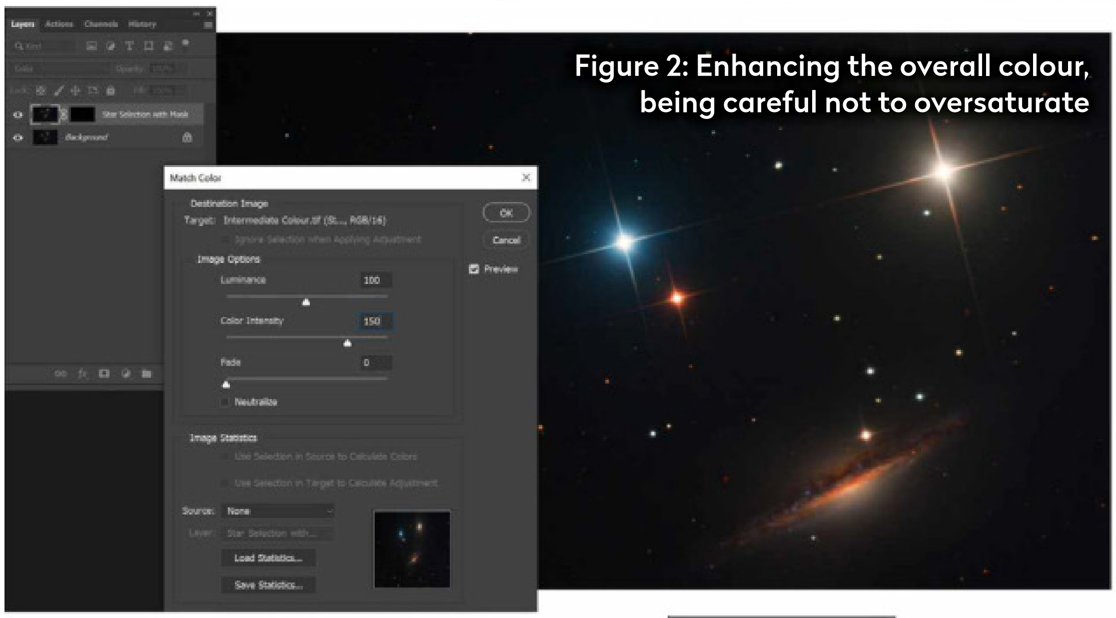


Figure 2: Enhancing the overall colour, being careful not to oversaturate

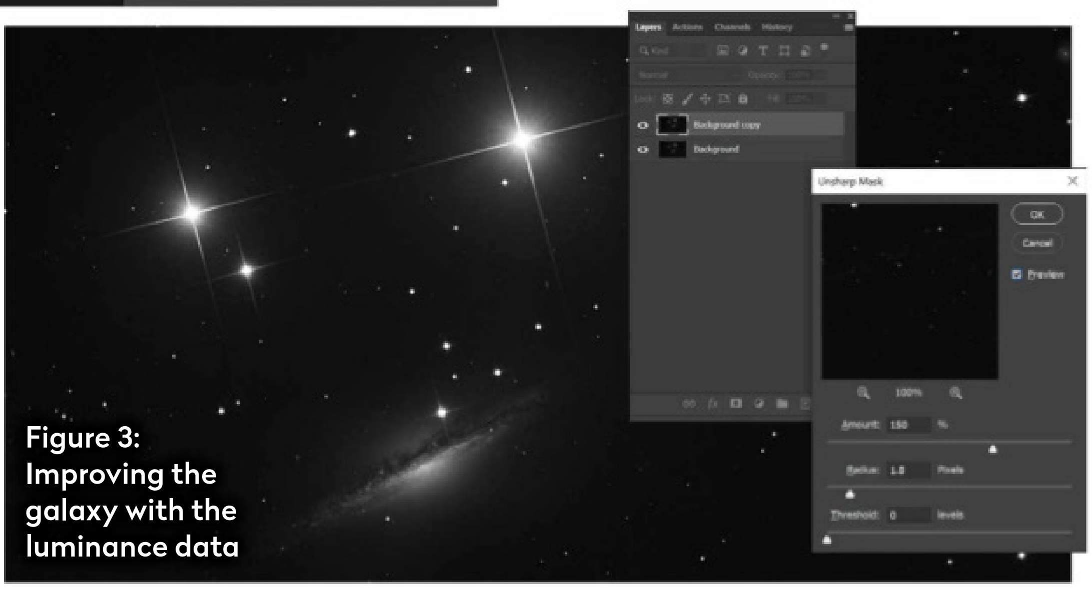


Figure 3: Improving the galaxy with the luminance data

▲ **Figure 4: The final, selective application of sharpened luminance**

3 QUICK TIPS

1. Apply the 'Match Colour' technique to the galaxy only, using a selection or mask.

2. Be careful not to over-sharpen. Sharpen selectively and only on areas of high signal-to-noise ratio.

3. Mild blurring of the stars helps to restore colour and smooths out pixelation.

colour slider to 150. Next, I changed the blend mode of this new layer to 'Colour' then flattened and repeated until I was satisfied with the desired level of colour saturation. I then created a precise star selection and saved that as a new channel. The very large stars were excluded as I prefer to deal with those separately.

A 'Reveal Selection Layer Mask' was added to the star selection and treated to a mild 0.5 pixel Gaussian blur before applying the 'Match Colour' filter. This star layer was set to 'Colour' blend mode and then flattened. Again, this technique was repeated until my desired level of saturation was achieved. Using a layer mask ensured that I did not oversaturate the galaxy and add colour noise to the background (see Figure 2).

Sharpening the dust lanes

Next up was resolving and improving the dust lane, where the high-quality luminance data – captured separately – comes into play. I layered the sharpened luminance image on top of the colour image and set the luminosity blend mode opacity to 50 per cent. The two layers were then flattened and the whole image treated to just enough noise reduction to smooth out the noise added by the sharpened luminance.

When adding luminance, the colour can become washed out, so to compensate I applied another iteration of 'Match Colour' but reduced the impact by lowering the opacity of the 'Colour' layer to 50 per cent. The sharpened luminance was then reapplied with the blend mode set to 'Luminosity' at 70 per cent opacity. On this occasion, however, I applied a 'Hide All' layer mask and used the brush tool to reveal the sharpened galaxy only (see Figure 3).

Then it was time to address the colour and size of the two large foreground stars. Here I used the 'Ellipse' tool to draw a selection around the large yellow-white star. I feathered the selection by 15 pixels so that any transitions in colour or texture were smooth. I then applied a curves adjustment, lowering the blue channel only to achieve a deeper yellow. While the selection was still active, I applied a two-pixel radius minimum filter (Filter › Other › Minimum) and set the 'Preservation' option to 'Roundness'. This reduced the size of the star, making it less prominent. I repeated this procedure on the blue-white star, but lowered the red channel in the curves adjustment (see Figure 4).

Finally, I reloaded the star selection created earlier and applied a very small amount of unsharp masking to make them shine, producing the final image you see on the page opposite.

Your best photos submitted to the magazine this month

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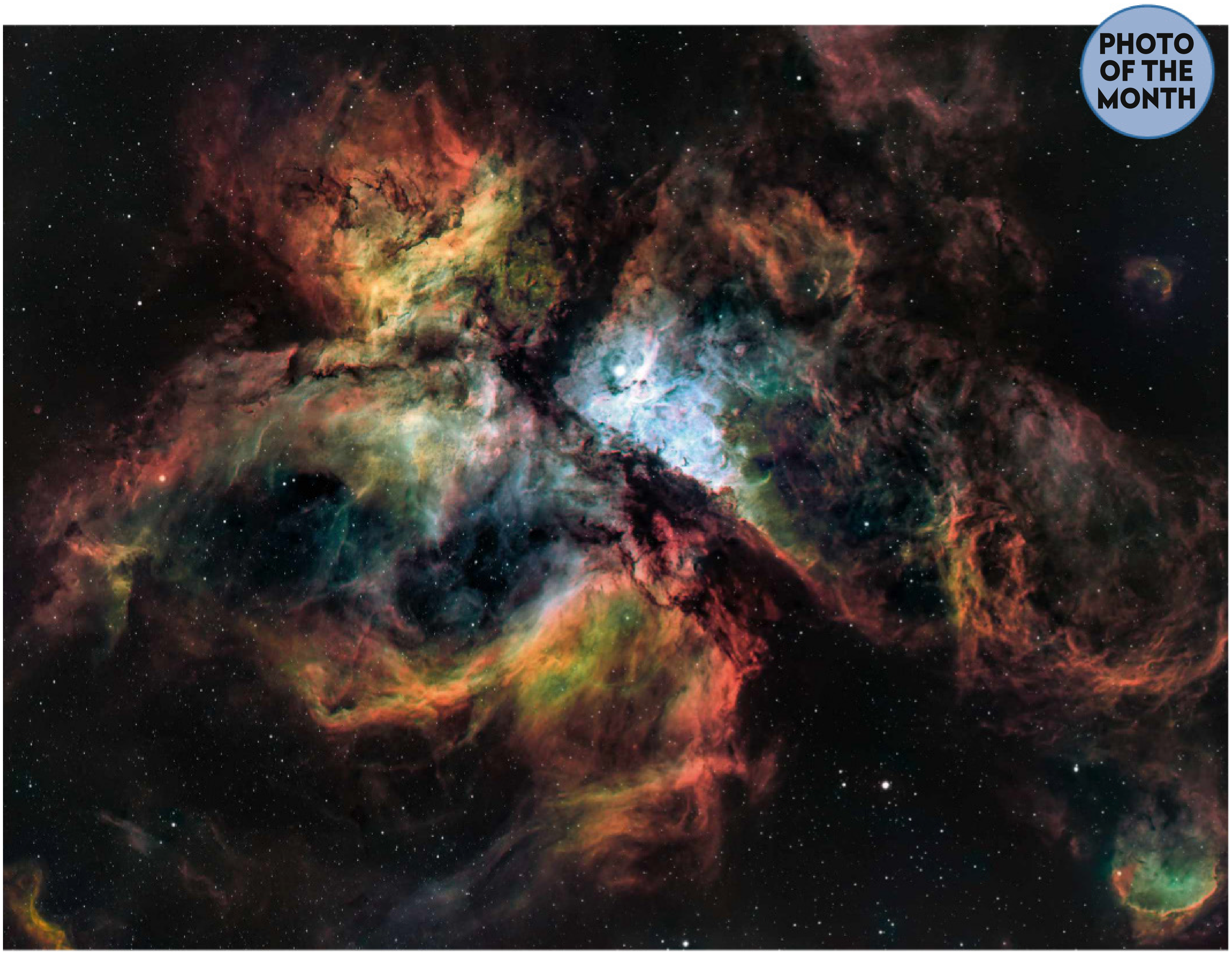
A gallery containing these and more of your images

PHOTO OF THE MONTH



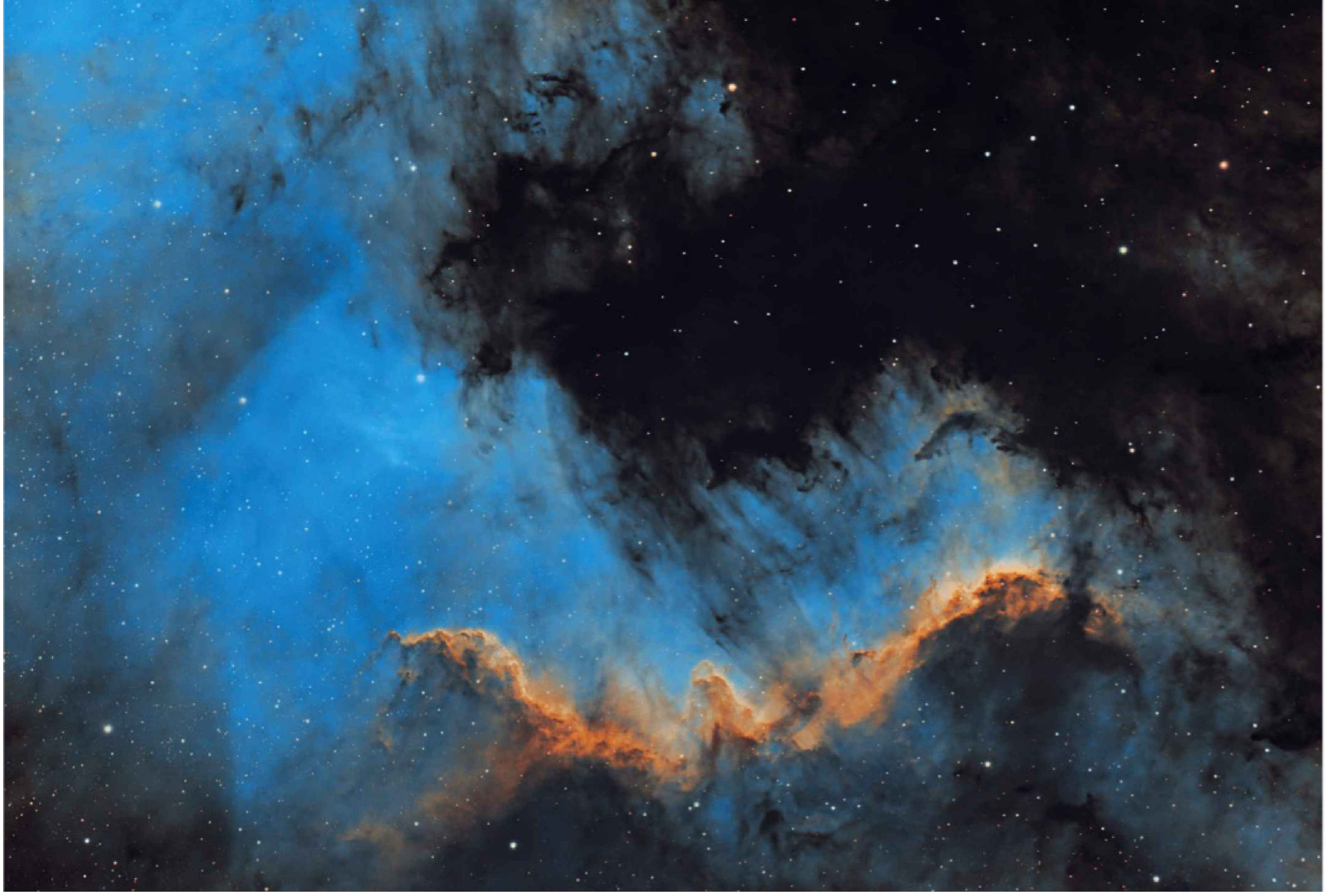
△ Eta Carinae

Taranjot Singh, Brisbane, Australia, 12 March 2022

Taranjot says: "I started my journey in deep-sky photography from this nebula and shot it with my DSLR. The moment I saw the first image, I felt something really amazing. Since then I wanted to photograph this target as well as possible. The only difficulty I had was the cloudy weather, so this photograph is the result of multiple sessions."

Equipment: ZWO ASI1600MM Pro camera, Askar FRA400 f/5.6 astrograph, Sky-Watcher EQ-6R Pro mount
Exposure: Hα 60x 3', SII 40x 3', OIII 40x 3'
Software: APP, PixInsight, Photoshop

Taranjot's top tips: "Make sure that your mount is polar-aligned accurately and well balanced with counterweights. This helps to track and frame your target more easily. I check for sharpness every 10–15 images and adjust as necessary. Take calibration frames to remove all the unwanted artefacts, and stack and stretch the image carefully, keeping dynamic range in mind. I convert each stack into a starless version using StarNet++, as this helps to bring out the structure of the target. Don't be afraid to experiment with levels, curves, filters and noise removal in Photoshop."



△ The Cygnus Wall

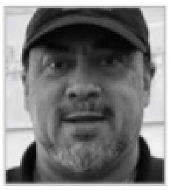
Larry Byrge, Jacksonboro, Tennessee, USA, 29 May 2022

Larry says: "This target is very hydrogen-rich, ideal for a multi-bandpass narrowband filter with my one-shot colour camera. It gave me an opportunity to try post-processing the data in the SHO colour palette."

Equipment: ZWO ASI294MC Pro camera, Explore Scientific ED102 refractor, Sky-Watcher EQ6-R mount
Exposure: 72x 300" **Software:** DeepSkyStacker, Photoshop, Starnet++

◁ The Sun in Hydrogen Alpha

John Chumack, Dayton, Ohio, USA, 18 June 2022



John says: "It is wonderful to see a very active Sun once again. There were nine active regions on the Sun on this day, along with many sunspots and a large filament stretching at least 370,100km. That's almost the distance from the Earth to the Moon."

Equipment: QHY5L-II CMOS camera, Lunt 60mm 50HA filtered solar telescope, Bisque MyT mount **Exposure:** 64ms, 480 frames **Software:** RegiStax, Adobe RAW

◁ The Pinwheel Galaxy

Gary Opitz, Rochester, NY, USA, 2, 3, 4, 8 June 2022

Gary says: "I chose M101 because it's one of the most beautiful of all the iconic spiral galaxies. I was using a new camera with quite high resolution and I'm very happy with how it turned out."

Equipment: ZWO ASI2600MM Pro camera, TEC 140 f/7 refractor, Orion Atlas EQ-G mount **Exposure:** 6h **Software:** PixInsight, Photoshop

△ Shades of Betelgeuse

Soumyadeep Mukherjee, Kolkata, India, 14 October 2021

Soumyadeep says: "I wanted to bring science and art together in an image. One of the challenges was that I had no reference image to look at before creating this."

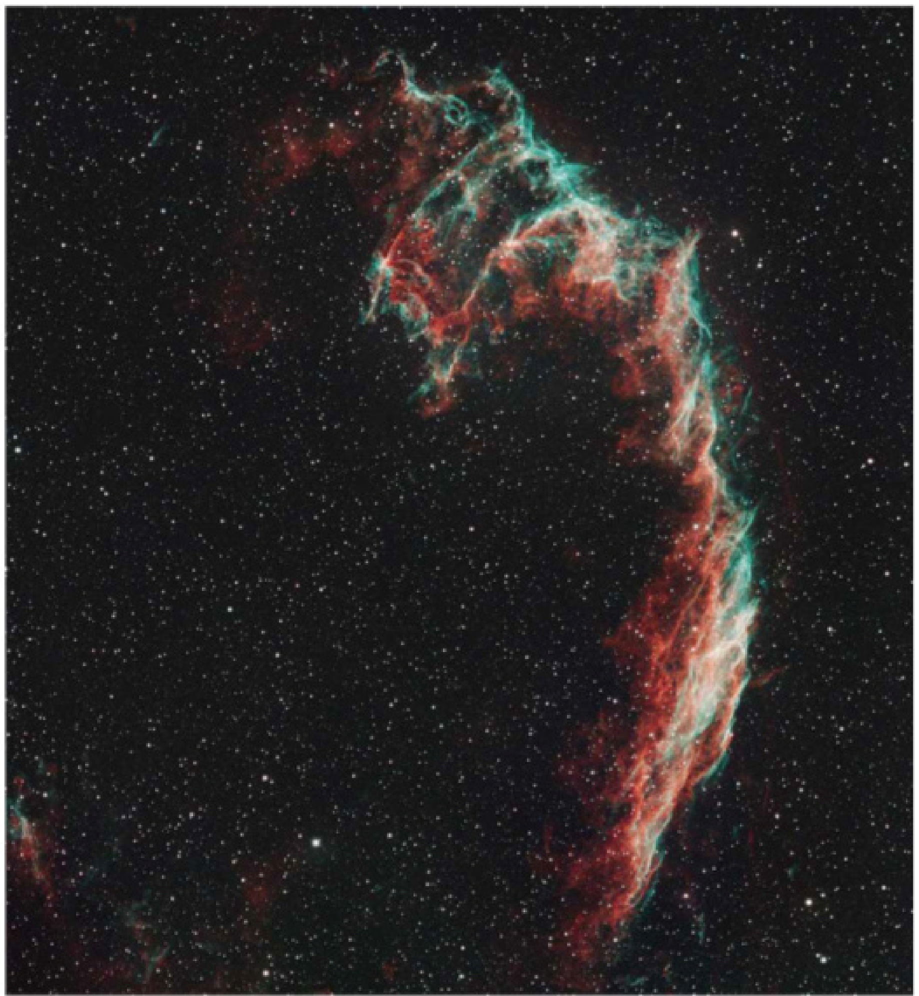
Equipment: Nikon D5600 DSLR, Sigma 150–600mm lens, tripod
Exposure: ISO 1000 f/6.3, 258x 1/3", 498x 1/6", I544x 1/8"
Software: AutoStakkert!, Photoshop, Topaz DeNoise

▽ The Eastern Veil Nebula

Martin Bracken, Chelmsford, Essex, 13–17 June 2022

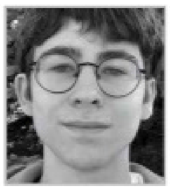
Martin says: "This is one of my favourite targets. I had to use a dual-band filter due to a lack of astronomical darkness, and this highlights the hydrogen alpha (red) and oxygen (blue) elements in the clouds of ionised gas, giving rise to the intricate details in the structure."

Equipment: ZWO ASI294MC Pro camera, Sky-Watcher Esprit 100ED refractor, Sky-Watcher HEQ5 Pro mount **Exposure:** 104x 300" **Software:** PixInsight, Photoshop



◁ The North America Nebula

Christopher Kelly-Brown, Strabane, County Tyrone, 31 May 2022



Christopher says: "On the one clear night in my half-term holiday I imaged the striking North America Nebula. I wasn't sure how it was going to turn out, but there's an interesting balance between the nebula and the fainter dust. I'm very happy with the result!"

Equipment: Nikon D5300 DSLR, Soligor 135mm lens, Sky-Watcher Star Adventurer mount
Exposure: 6x 60"
Software: Siril, GIMP, Lightroom

The Monkey Head Nebula, NGC 2174 ▷

Andrei Pleskatsevich, Minsk, Belarus, 12 January 2022

Andrei says: "Not many beginners know you can use the HOO palette with one-shot colour cameras. If you have a good narrowband filter then you can use the R channel as H-alpha, and the G and B channels as OIII, then process your image in HOO."

Equipment: ToupTek ATR3C571 camera, SharpStar 76EDPH f/4.5 refractor, Radian Triad Ultra 2-inch filter, iOptron GEM28 mount **Exposure:** 16x 600"
Software: DeepSkyStacker, Photoshop

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86 **Big aperture that won't break your back or your bank balance – we review the new StellaLyra Dobsonian**

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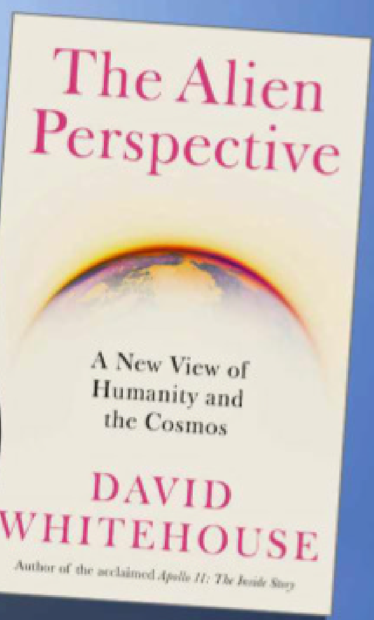

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good ★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

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Our experts review the latest kit

FIRST LIGHT

StellaLyra 8-inch f/6 Dobsonian

Large aperture plus portability? This robust all-rounder strikes the perfect balance

WORDS: CHARLOTTE DANIELS

VITAL STATS

- **Price** £429
- **Optics** Newtonian reflector, parabolic primary mirror
- **Focal length** 1,200mm, f/5.9
- **Finderscope** 8x50 right-angled
- **Eyepieces** 30mm 2-inch Superview, 9mm 1.25-inch Plössl
- **Extras** 2-inch focus extension tube, 2-inch to 1.25-inch eyepiece adaptor, cooling fan, eyepiece tray
- **Weight** 20.9kg
- **Supplier** First Light Optics
- **www.**firstlightoptics.com

The StellaLyra 8-inch f/6 Dobsonian is made by well-regarded manufacturer Guan Sheng Optical (GSO) in Taiwan, and arrived in two boxes, one for the optical tube, and the other containing all the accessories and the flat-packed base. Also included were an 8x50 right-angled finderscope, 30mm 2-inch Superview eyepiece, 9mm 1.25-inch Plössl eyepiece and a 35mm 2-inch focus extension tube. The manual is available to download from First Light Optic's website. The assembly instructions consisted of a single image, which was fairly easy to interpret, though beginners might benefit from a more thorough step-by-step manual. Nevertheless, we had it set up in 25 minutes.

The build quality was largely excellent, with minimal plastic and robust accessories. We did note that the base was made from chipboard and some edges were not fully coated with paint. While it was strong and solid, this could make it vulnerable to moisture. While the assembled setup is heavy, the tube is easily lifted away from the base, which itself can then be carried using a handy carry handle. The StellaLyra is therefore relatively easy to move around.

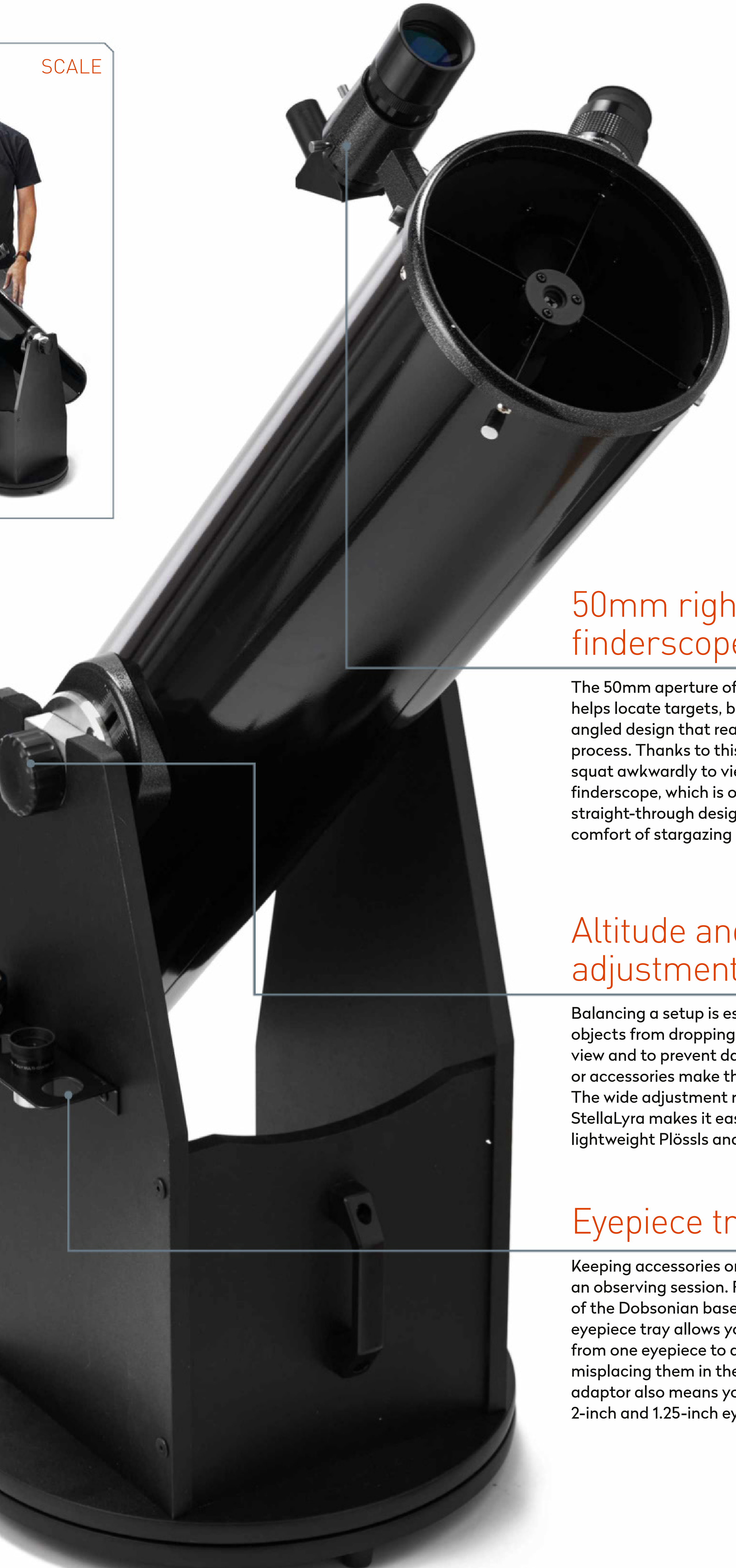
Adjusts with ease

We were impressed by the large collimation knobs and were able to collimate the optics in under five minutes. Next, we used the altitude adjusters on the side of the tube to balance the setup – again, an easy process thanks to the large adjustment knobs, a nice addition by StellaLyra. The built-in tension adjustment allowed us to get the right amount of resistance for tilting the tube, while the base also had a separate tension adjuster that allowed us to customise the resistance of the 'lazy Susan'-style swivel base.

Ready to put the Dobsonian through its paces, we popped the 30mm eyepiece in, finding we could not focus. However, adding the provided extension tube resolved this. Oncc focused, the field of view was lovely and flat, with stars sharp from edge to edge.

The manoeuvrability of the reflector on its base was very smooth and we found it easy to make minor adjustments. First up in our tour of the skies, we popped over to a waning Moon. While the aperture meant that the Moon was very bright, we felt we could almost reach out and touch the craters and we ▸

ALL PHOTOS: @THESHED/PHOTOSTUDIO



50mm right-angled finderscope

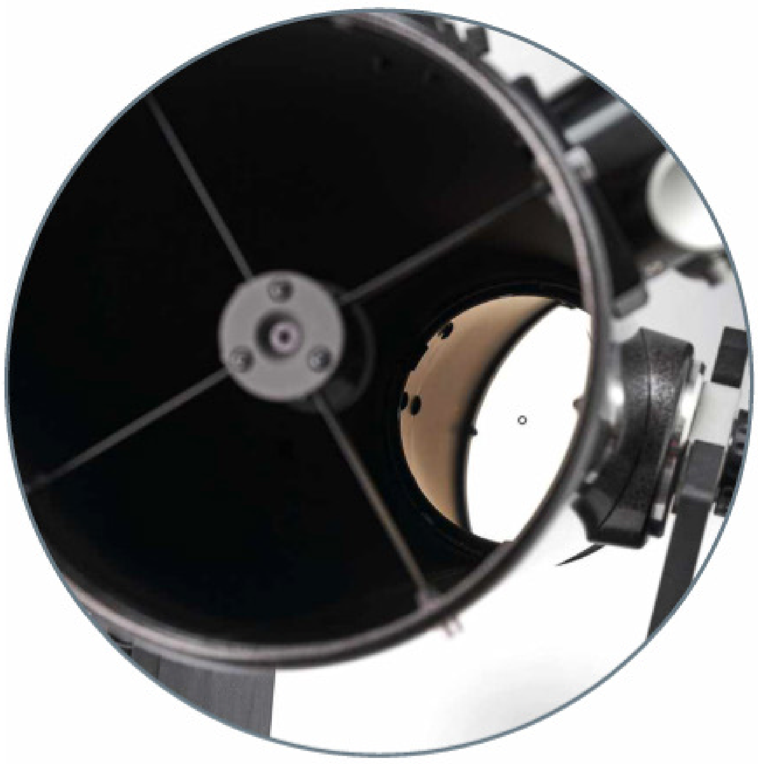
The 50mm aperture of the finderscope helps locate targets, but it is the right-angled design that really optimises the process. Thanks to this, you don't have to squat awkwardly to view through the finderscope, which is often the case with a straight-through design. This increases the comfort of stargazing sessions.

Altitude and tension adjustment knobs

Balancing a setup is essential to prevent objects from dropping out of the field of view and to prevent damage when cameras or accessories make the setup top-heavy. The wide adjustment range of the 8-inch StellaLyra makes it easy to balance lightweight Plössls and heavier eyepieces.

Eyepiece tray

Keeping accessories organised really helps an observing session. Fastened to the side of the Dobsonian base, this all-metal eyepiece tray allows you to easily switch from one eyepiece to another without misplacing them in the dark. The provided adaptor also means you can use both 2-inch and 1.25-inch eyepieces.



Ideal optics for an all-rounder

The 8-inch aperture makes the StellaLyra a brilliant all-rounder telescope for both beginner and intermediate astronomers. The diameter opens opportunities for lunar, planetary and deep-sky viewing, which not only encourages those new to astronomy, but provides enough stargazing potential to keep more seasoned amateurs interested.

The 1,200mm focal length gives a good balance of providing decent fields of view for both larger and smaller deep-sky objects, through the use of higher- and lower-powered eyepieces, but it is the aperture that optimises the StellaLyra's light-gathering ability, while still allowing it to be a portable setup.

Thanks to the fields of view provided, pleasing levels of detail can be resolved from fainter, delicate objects, including star clusters and galaxies. And because of the focal length and the Dobsonian design, the eyepieces are at a comfortable level, meaning you can stargaze while sitting down. For grab-and-go convenience, the optical tube assembly can then be removed from the base and carried using the altitude adjusters as handles.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

CNC-machined 2-inch dual-speed Crayford focuser

The robust, well-made focuser is easy to use. It has both a tension adjuster and a focus lock, meaning there's no risk of slippage. The integrated, easy-to-read measurement scale is an excellent addition, allowing users to remember focus positions for various eyepieces, while the extension tube ensures focus for a range of high- and low-powered eyepieces.

Primary mirror cooling fan

The cooling fan, powered by eight AA batteries, is fastened to the base of the optical tube. It proves especially useful during colder months, when transferring the 8-inch StellaLyra from indoor temperatures to outside. The fan allows rapid cooling of the primary mirror, reducing the effect of thermal distortions and therefore preserving the optics.

▸ enjoyed exploring the surface while waiting for the skies to darken a little more.

Keen to see some deep-sky objects, we star-hopped across to Hercules for the Great Globular Cluster, M13. Using the right-angled finder allowed us to do this easily and the only improvement we felt could be made was the addition of a red-dot finder for those new to astronomy. Switching to the 9mm eyepiece provided very clean views of the cluster and we were able to resolve stars in towards the core. Optically, we had no complaints about the 9mm, but noted that it gave little eye relief, which took a bit of getting used to. In terms of build quality, while it was a metal eyepiece, we didn't think it was quite in the same league as the 30mm.

Encouraged, we decided to try M57, the Ring Nebula, and through the 9mm eyepiece we were able to see a fair bit of detail and structure. Keen to test the 9mm a little further, we popped across to the Double Double star, Epsilon Lyrae, which we weren't quite able to split into its four parts, but we had no problems resolving Mizar (Zeta Ursae Majoris).

The StellaLyra remains just on the right side of portability and, thanks to the robust collimation system, should hold alignment if moved around. We thoroughly enjoyed trying out this 8-inch Dobsonian, which despite packing plenty of resolving power is the smallest aperture in the StellaLyra Dobsonian range. Indeed, we lost track of time scanning the night sky. With its complete set of accessories, it will keep astronomers happily stargazing for years to come.

VERDICT

Assembly	★★★★☆
Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. StellaLyra Premium Cheshire Collimating Eyepiece

2. StellaLyra ED Deluxe 2-inch 2x Barlow lens

3. Astro Essentials ND96-0.9 1.25-inch Moon filter

Our experts review the latest kit

FIRST LIGHT

Sky-Watcher Evolux 62ED refractor

Whether stargazing or astro imaging, this travel-friendly scope gets the job done

WORDS: PAUL MONEY

VITAL STATS

- **Price** £359
- **Optics** Apo ED air-spaced doublet
- **Aperture** 62mm
- **Focal length** 400mm, f/6.45
- **Focuser** 2.4-inch dual-speed
- **Weight** 2.5kg with supplied accessories
- **Extras** Retractable dew shield, Vixen-style mounting bar, carry case, two findershoe adaptors
- **Supplier** Optical Vision Ltd
- **Tel** 01359 244200
- **www.** opticalvision.co.uk

Big is beautiful, or so they say, but small can hit the spot too. This month we test whether that's true of Sky-Watcher's latest high-quality, compact, apochromatic refractor, the Evolux 62ED. There is also an 82mm aperture version for those who are looking for that little bit more aperture.

The Evolux 62ED is supplied as an optical tube only, but comes with a 45mm Vixen-style bar for mounting, attached via a clamshell ring. This clamshell ring is equipped with two findershoes for adding other accessories, such as a lightweight red dot finder and a small guidescope for imaging. The clamshell can be easily loosened off to rotate the tube or adjust its position to aid in balancing the setup. The short-tube refractor also comes with a handy aluminium carry case. Note, however, that for visual use you would need to add a 2-inch star diagonal, eyepiece and finderscope.

At the front end, nicely protected by an extendable dew shield, is the 62mm f/6.45 apochromatic objective lens. This has a focal length of just 400mm and with the dew shield retracted is just 295mm long, which is reasonably compact. Indeed, weighing in at only 2.5kg, the Evolux 62ED is aiming to be an ideal grab-and-go system.

The apochromatic optics eliminate colour fringing – when all three primary colours are not brought to a common focus point. We found that stars were pin-sharp across three-quarters of the field of view when using a 26mm eyepiece, with little evidence of any colour fringing.

The business end

At the other end we have the focuser, which by our measurement gives 65mm of focus travel, with a graduated scale that will be useful for those wanting to note the focus point for different cameras and return to it easily later. Interestingly, the focuser has two tension screws, top and bottom, and these ensure focus is set, with no slippage when using heavy cameras that we could note.

We did some visual testing first, adding our own 2-inch dielectric star diagonal and 2-inch, 26mm eyepiece to explore along the Milky Way. We really enjoyed sweeping up the star clouds from Cygnus down into Serpens. Along the way, the wide field of ▸

Optics

The objective lens is 62mm in diameter with a focal length of 400mm, which gives a focal ratio of f/6.45, making the system quite compact. The optics involve a fully multi-coated air-spaced doublet lens, with lens elements featuring Sky-Watcher's Metallic High-Transmission Coatings for a claimed light transmission of 99.5 per cent.

SCALE

Dew shield

The dew shield is retractable, with two locking screws to keep it in place when extended. It only adds 75mm to the overall length when extended, and when retracted the refractor is very short at just 295mm. It worked well, allowing over 1.5 hours of imaging before the lens began to dew up.

Clamshell ring and mounting bar

Being quite small, the Evolux 62ED is equipped with a clamshell ring and tripod foot. The clamshell ring can be loosened to help rotate the tube and the foot is equipped with a 45mm Vixen-style mounting bar, which can also be attached to a typical photographic tripod.

Focuser

The focuser is a 2.4-inch, 11:1 dual-speed, rack-and-pinion design and has 65mm of focus travel, with a very useful indexed scale so you can quickly achieve focus and record the position for later use. The focuser body also has two large thumbscrews to tension the focuser when using heavy equipment.

FIRST LIGHT

Carry case

The Evolux 62ED is supplied with an aluminium carry case, fully padded for storing and transporting the telescope safely to other sites or for taking abroad as a travel scope. There are plenty of foam inserts that can be removed to add accessories such as eyepieces and filters.

Light and portable

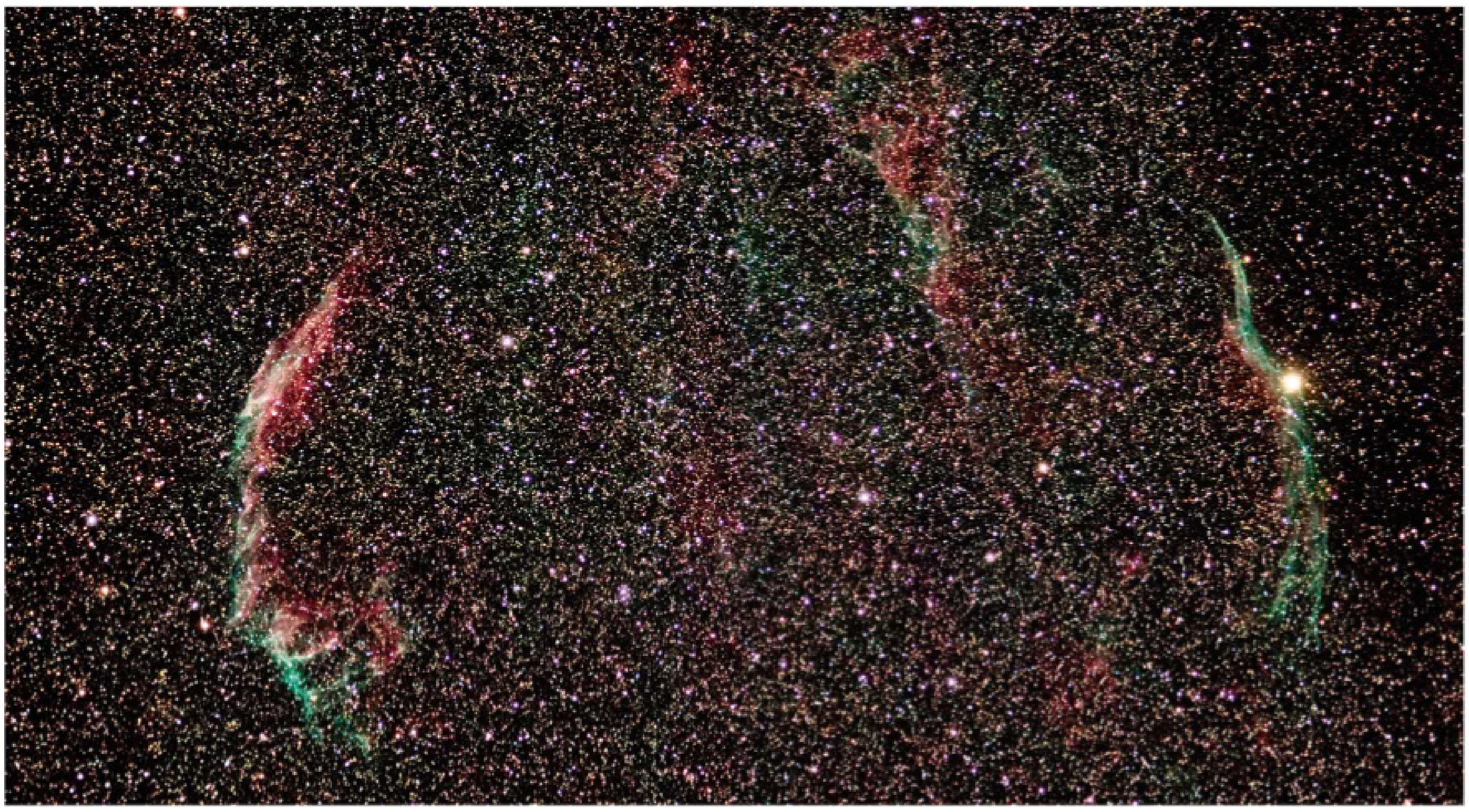
Grab-and-go telescopes for observing and imaging have become all the rage, especially since travel resumed after the pandemic, so the Evolux 62ED has come at the right time. It is compact at just 295mm and lightweight at 2.5kg (just more than the weight of a typical bag of sugar), making it ideal as a travel scope. Its compactness with a retractable dewshield lends itself to the other craze for lightweight, highly portable mounts.

We found it made a great optical instrument when paired with Sky-Watcher's Star Adventurer mount, and they even have pleasingly matching colour schemes. It can also be mounted on a photography tripod. Add a diagonal and eyepiece and you have a spotting scope, either for stars or nature watching, making this a versatile instrument.

Its other strength, however, is imaging: widefield images of the Milky Way's star clouds, dark dust lanes, large clusters – with its generous field of view, there are plenty of targets to keep you imaging or viewing for a long time to come.


Our reviewer was delighted with the details visible on the lunar surface


▲ Paired with a Canon R6 camera to capture globular cluster M13. A stack of 56x 30" exposures at ISO 6400


◄ The complete Veil Nebula fitted in the field of view. Same camera, 90x 30" exposures, ISO 6400

► view did mean that most typical deep-sky targets, like nebulae and clusters were presented small, but we expected that. Even so, M39 stood out well and adding a 2x Barlow lens showed that even some double stars could be split. We viewed Albireo (Beta Cygni) with its golden and sky-blue components, then just about split Mizar (Zeta Ursae Majoris) into two unequal stars very close together.

We also spotted Saturn and Jupiter in the early hours. As expected they were small, but we could see the rings of Saturn and two bands on Jupiter as well as four of its retinue of moons. Our Moon, meanwhile, was an enjoyable and detailed sight.

To image with the Evolux 62ED and get the best out of the system, we were loaned the optional 0.9x ED flattener/focal reducer. This is attached by unscrewing the metallic green, 2-inch visual adaptor then screwing in the flattener. To attach a camera, you need an M48 x 0.75 adaptor. These are specific to your particular camera manufacturer, so be sure to order the right one.

With a Canon R6 camera attached, we took 128x 30" exposures of the star Sadr in Cygnus and its surrounding area at ISO 6400, and were very pleased with the detail and nebulosity we achieved. We did the same with the Veil Nebula, this time with 90 images stacked, to show you can capture the entire supernova remnant in the field of view. M13, the Hercules Globular Cluster, was imaged with 56 exposures, and we could pick out its tiny neighbouring galaxy NGC 6207 in the image too.

Overall, this is a thoroughly competent grab-and-go travel scope which we can highly recommend.

VERDICT

Build & Design	★★★★★
Ease of use	★★★★☆
Features	★★★★☆
Imaging quality	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

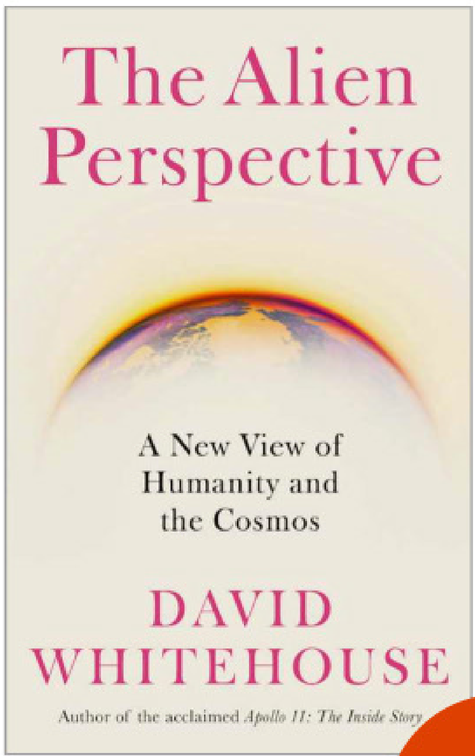
KIT TO ADD

1. Sky-Watcher 0.9x ED flattener for Evolux 62ED

2. Sky-Watcher aluminium accessory handle for Evolux 62ED

3. Sky-Watcher 2-inch Deluxe Dielectric Star Diagonal

BOOKS



The Alien Perspective

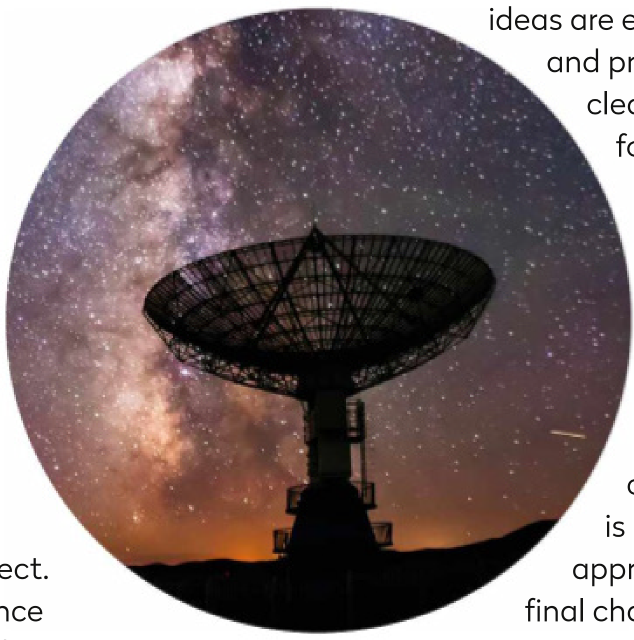
SETI SCIENCE

David Whitehouse
Icon Books
£17.99 ● HB

Are we alone in the Universe? The possibility of intelligent aliens has fascinated humanity for centuries, but David Whitehouse's new book takes a refreshingly different approach to the subject. The former BBC science correspondent considers not only the familiar questions about life elsewhere in our cosmic neighbourhood, but also what our speculations on the subject reveal about humanity, and the profound shifts in perspective that might come from the confirmation of extraterrestrial life.

Whitehouse's canvas is broad and painted with a wealth of historical and scientific details, as he leads our attention seamlessly from one aspect of his varied subject to another. Here, a rumination on the relationship between our prehistoric ancestors and the cosmos; there, an account of early attempts at SETI (the Search for Extraterrestrial Intelligence). Companion chapters near the start and end take the reader through imaginary museums chronicling the astonishing variety of life on Earth, and the myriad possible paths that might be taken by life on other worlds. There are discussions of the religious and diplomatic fallout from contact with intelligent life, to the design of our own attempts at communication.

Whitehouse's background in radio astronomy makes him well suited to give an account of detection and communication efforts that are still heavily focused on 'big dish' astronomy, but other possibilities – the detection of 'technosignatures' around distant stars and even alien spacecraft (crewed or automated) visiting our Solar System – are also considered. Often-complex ideas are explained with clarity and precision, but this is clearly a passion project for the author, and the book soars where he deploys more poetic language, as when musing on the deeper themes that arise from his central question. This is nowhere more appropriate than in the final chapters, where Whitehouse considers the possibilities of life outlasting the stars around which it is born, and how it might find ways of surviving to the ends of the Universe itself.


▲ **Is anybody out there? For Whitehouse, finding ET is just the start**

ZHENGZAISHURU/ISTOCK/GETTY IMAGES

If you've ever looked up at the sky and pondered on the big questions of life in the Universe, this is essential reading.
★★★★★

***Giles Sparrow** is a writer and author on popular science*

Interview with the author
David Whitehouse

How has the telescope changed humanity?

From Galileo's crude 'optik tube' 400 years ago to the James Webb Space Telescope, the telescope in its various forms has shown us our true place in the cosmos. Once we strained to discern the features on Mars. Now we contemplate scrutinising the atmospheres of planets orbiting distant stars a billion, billion times further away. No other scientific instrument has done so much to place our species into its cosmic context.

Are we on the cusp of finding life beyond Earth?

We do not know where we will find the first signs of other life in the cosmos. Perhaps we'll discover microbes deep below the radiation-blasted sands of Mars, or life signs in the spectral bands of planets circling nearby stars. Will it be a message in radio form, a laser flash or a stream of quantum-entangled particles? Perhaps we'll find an artefact of a long-dead race or be visited by alien spacecraft. It could happen today, or never.

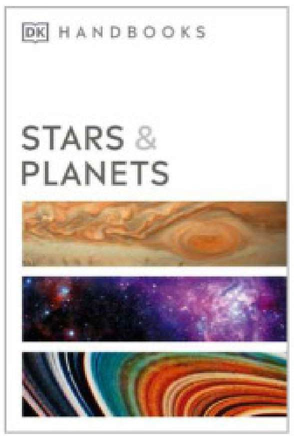
What would it mean to discover intelligent life?

How would beings, born under the light of another star, or in the spaces in between them, view the cosmos and ourselves? Could we ever know them or would they forever be a mystery of the adjacent possible? The view of humanity through an alien eye might be something that could liberate or terrify us. Until we find them we will not be ready, and afterwards it will be too late.

***David Whitehouse** is a former BBC science correspondent and science editor, and has written several books*

Stars and Planets

Ian Ridpath
DK
£9.99 ● PB

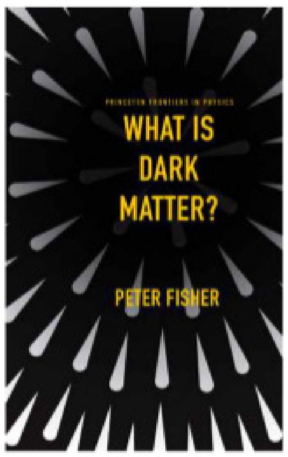


Ian Ridpath is one of the biggest names in astronomy. With over 40 books under his belt, he knows what he's talking about, communicating a range of subjects to amateur astronomers with ease. His handbook, *Stars and Planets*, is split into the Solar System, the constellations and monthly sky guides. It concisely explains the basics, offering the beginner a fine introduction to star formation, nebulae, the celestial sphere and how to use your hand as an astronomical measuring scale. The two-page binocular and telescope guide is enough to help any keen observer get to grips with the equipment available to them. In the Solar System section, each planet is described including concise facts about atmosphere, climate, geography and geology, and charts present the location of each one in the morning and evening sky from 2022 to 2033. High praise needs to be given to the pages dedicated to the 88 constellations. The reader is invited to learn about their mythology, their position in the sky and how to view features of interest within each one, such as deep-sky objects. The brilliant monthly sky charts in the last section of the book will help you locate the constellations throughout the year. The layout and detail of *Stars and Planets* is simply wonderful. If you are looking for an imaginative astronomy book packed with easy-to-understand text, beautiful glossy images and useful star charts then you've found it. ★★★★★

***Katrin Raynor Evans** is an astronomy communicator and writer*

What is Dark Matter?

Peter Fisher
Princeton University Press
£28 ● HB



Scientists have known about dark matter for nearly 40 years. They have confirmed its existence by observing its gravitational effect on galaxies and understand that it makes up 27 per cent of the mass-energy of the Universe, but they are still unsure what it is. So writing a book titled *What is Dark Matter?* would seem perverse. However, this is a very scholarly look at the historical theories, research and experiments on the evidence for, and the properties of, dark matter.

The book is fast-paced and the reader will need to concentrate to keep up. There are few helpful analogies and no hand-holding. Knowledge of scientific notation and mathematical expressions, and being able to understand complex diagrams and equations is assumed. It is well worth taking the time to get to grips with the principles laid out in the first chapter before moving on, and there is a useful glossary of terms to guide you.

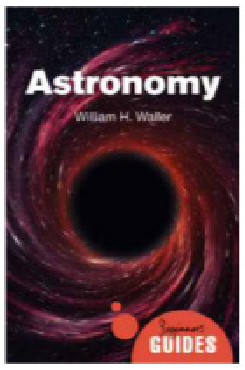
The book is very well written. It takes you through the problems of uniting dark matter with the Standard Model via supersymmetry and Modified Newtonian dynamics. It details the ongoing search for WIMPs (weakly interacting massive particles) and axions, explaining the need for bigger, more sensitive detectors and telescopes, with longer observing runs, to find them.

This is not a book for a novice; a grounding in astrophysics is helpful but not essential. By the end, you will have a better understanding, not of what dark matter is, but at least of what dark matter isn't and what it might be. ★★★★☆

***Jenny Winder** is a freelance science writer, astronomer and broadcaster*

Astronomy: A Beginner's Guide

William H Waller
Oneworld
£9.99 ● PB



This beautiful little book offers, as its name suggests, a beginner's guide to the Universe. And author William Waller, with a sturdy academic background in astrophysics and astronomy, goes about his task with gusto. He comprehensively introduces the wonders of the cosmos, venturing steadily outward from Earth, to the wider Solar System, to the barely comprehensible infinity beyond.

By his own admission, *Astronomy: A Beginner's Guide* is intended by Waller to be "digestible" for the growing legions of sky-watchers – "not quite one in a million, but certainly getting there"– as this oldest-known science gains new traction in the 21st century. Both the book and Waller himself are clearly driven by what he describes as "the ever-compelling wonders of the night sky".

He traces our study of the heavens wheeling above our heads over multiple nations, cultures and millennia, looking first at the peculiarities of our own world as a convenient and relatable point of reference, then migrating outward on a journey to take in the Sun, "a god over mortals", the giant planets Jupiter and Saturn, "bullies on the block", and the wider Universe far beyond, including the lure of life.

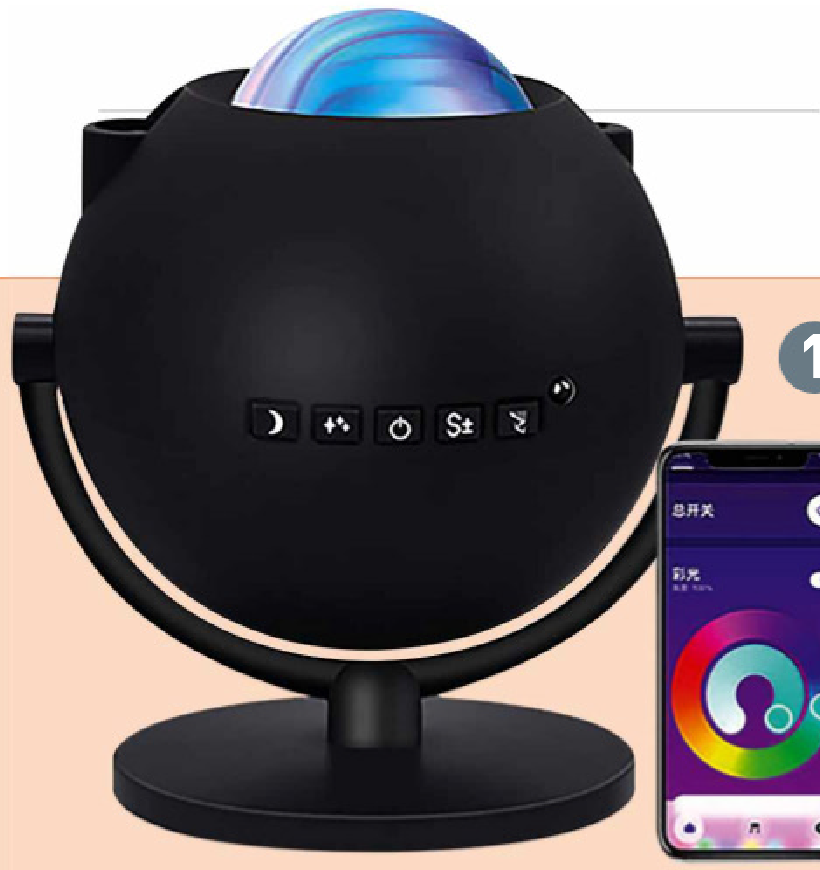
Waller heartily regales us with tales of his own experiences, notably sitting in a carpeted, windowless room at the University of Washington one sweltering August night in 1989 when "the first transmitted images of Neptune, from Neptune" arrived, via Voyager 2.

All in all, this exquisite gem dips its toe often enough into a complex mire of scientific and mathematical minutiae to maintain strong intellectual rigour, yet its core remains sufficiently readable to sustain and fire the interest of the non-academic reader. ★★★★☆

***Ben Evans** is a science and astronomy writer and the author of several books*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR



1 Aurora borealis projector

Price £95 • **Supplier** Encalife • **www.encalife.com**

The Northern Lights are unpredictably elusive, but with this projector you can see them every night without having to leave your living room. The device projects a dancing pattern of colours and can be controlled using the remote or your smartphone.

2 Askar off-axis guider adaptor

Price £179 • **Supplier** 365 Astronomy • **www.365astronomy.com**

Fix your guider directly to the eyepiece so it has the same view as you or your astro camera, helping it create an accurate lock on the night sky. The adaptor has multiple threads, so it's compatible with most accessories and cameras.

3 What we see in the stars journal

Price £11.25 • **Supplier** WHSmiths • **www.whsmiths.co.uk**

If you're looking for an observing journal with a cover as beautiful as the night sky, then this could be it. Decorated with illustrations of the best-known constellations, inside are 160 dotted pages to keep your observations neatly aligned.

4 Buckeye Stargazer bubble level

Price from £15 • **Supplier** First Light Optics • **www.firstlightoptics.com**

Getting your tripod level helps ensure your telescope is correctly aligned. These bubble levels can either sit on the spreader bar or fit your tripod's equipment tray. Both 1.25- and 2-inch versions are available.

5 Celestron dew shield

Price £44.99 • **Supplier** Widescreen Centre • **www.widescreen-centre.co.uk**

This dew shield helps to keep moisture off your optics and also keeps out stray light. Made to fit 6- and 8-inch tubes, it has a cut out at the base to accommodate dovetail bars up to 4 inches wide. The tube can be rolled up easily for transport and storage.

6 Altair dualband 4nm CMOS filter

Price £399 • **Supplier** Harrison Telescopes • **www.harrisontelescopes.co.uk**

This filter transmits OIII and Ha light, suppressing almost all other unwanted light. Teamed with a colour CMOS camera, it helps create crisp, bright images, even under extremely light-polluted skies. It works with both modified and unmodified DSLR cameras and has an anti-reflection coating.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Melissa Brobby interviews Rajeev Suri

Q&A WITH THE CEO OF INMARSAT

A landmark study has found that, in contrast to the Apollo generation, younger people are out of touch with the realities of the space industry

Your report, 'What on Earth is the value of space?', was released recently. What was it about?

The report is the largest ever survey of public perceptions of space globally and included more than 20,000 people in 11 countries. The reason we did it is because we wanted to understand the public perception. What do people feel about space? Do people understand that space is adding value to their daily lives, what it does today and what it will do in the future? We want to understand what people are fearful of regarding space. We also wanted to know how people feel about space in different generations, because we want to recruit more people into our industry.

▲ A ticker-tape parade for the Apollo 11 astronauts in New York, August 1969, when public interest in space was at a high

How did you discover that Generation Z is taking less of an interest in space?

We found in the survey that those aged 18 to 24 seem to be guided more by science fiction and movies than a real understanding of what is happening in space. Those who lived through the first Space Age were more excited because of the Apollo missions. But now what we do in space has become somewhat invisible: space is used for weather forecasting, navigation and communications, connecting the unconnected, humanitarian missions, disaster recovery, in-flight Wi-Fi and agriculture. So I think since it's become more commonplace and invisible in our daily lives, it seems that young people don't have an understanding of what space does.

What topics *are* Gen-Z interested in around space, according to your study?

There are two topics that came up in the report. The first was a fear of space – an overwhelming majority felt fearful of space, space junk and space debris, while others were unaware of that. The other topics that came up were aliens and space tourism; space being a billionaire's playground as opposed to something that helps us on a daily basis. We saw that 21 per cent of people associated space with aliens, against just 8 per cent who associated the space industry with what it really does.

NASA

Were these findings surprising to you?

It was surprising that 97 per cent of people said they were fearful about the impact of the space industry, and about 35 per cent globally felt hopeful about space. I think it's reasonable that people have worries about space junk and damage to the Earth's atmosphere – I didn't know people were aware of that. I was also surprised by the lack of awareness of what space does. I think maybe in the days of Apollo people were more excited by the idea of space.

Do you think this study should serve as a wake-up call to the space industry?

I do, and I think it's important for us in this industry to do something about it because you need public trust. We want to recruit more people into the industry, we need people to be more aware of what space enables. We also have a role to play in educating people and creating the right kind of awareness.

Rajeev Suri is the CEO of Inmarsat, a British satellite telecommunications company that delivers mobile communications across the world

Do you worry that this decline in interest could result in less people going into the space sector?

I think I'm being realistic. We found from the survey that just 7 per cent of people in the UK want to work in the space industry, and globally that figure is 14 per cent. That's a concern because we want people to be attracted to our sector. We also think that the more people are aware of what we do in space, the greater the public interest will be. And that has a direct correlation, ultimately, to capital coming into the sector. In some ways it's not a bad thing that people think it's invisible in our daily lives, but as an industry, we need to create a more powerful and relatable narrative about space so that people understand what it does and what it really is about.


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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Marvel at big, bright Jupiter and take a swim around the stars of Delphinus, the Dolphin

When to use this chart

1 Sept at 00:00 AEST (14:00 UT)
15 Sept at 23:00 AEST (13:00 UT)
30 Sept at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

SEPTEMBER HIGHLIGHTS

Jupiter is at opposition this month, rising around sunset and visible the whole night. With Venus too close to the Sun, Jupiter is by far the brightest and largest of the planets visible. At close to 50 arcseconds across (around the biggest it gets), this is a great opportunity to observe the intricate cloud patterns in its north and south equatorial belts. The Great Red Spot is a target for any sized telescope and best seen around an hour before and after crossing the central meridian.

STARS AND CONSTELLATIONS

Watery constellations to see this month are the fishy ones (Pisces and Pisces Austrinus) and Aquarius, the Water Bearer. Lesser known is Delphinus, the Dolphin. This small constellation is faint, but distinctive, lying around 15° east-northeast (lower right) of bright Altair. Its main four 4th-magnitude stars are in a diamond shape known as Job's Coffin. A fifth star of similar brightness lies 3° south of (above) the diamond. Suburban dwellers may need binoculars to view.

THE PLANETS

For the first half of September, Mercury is close to the western horizon in the late twilight. Then turn around and find luminous Jupiter in the eastern evening sky. Saturn is already well placed, crossing the meridian (due north) around 22:00. Neptune takes the same passage about two hours later, followed by Jupiter at 01:00. Although visible late evening, Uranus is best left until mid-morning. Mars too arrives around midnight, but is at its best in the late morning.

DEEP-SKY OBJECTS

This month a quick swim to visit the Dolphin. As it's not far from the Milky Way, Delphinus offers some rich star fields. Embedded in one such field is the globular star cluster NGC 6934 (RA 20h 34.2m, Dec +07° 24'). Although an attractive view, this 9th-magnitude 'fuzzy' is only four arcminutes across and needs some power (150x) to see its two-arcminute-wide bright, condensed core; and some aperture (250mm) to begin resolving halo stars. There is a 9th-magnitude star on the western edge.

Now for a challenge! NGC 6891 (RA 20h 15.1m, Dec +12° 42') is a fairly bright (10th-magnitude) planetary nebula. However, you need to find it. Being in an isolated region (2.5° south of Rho Aquilae), at low power the nebula looks just like a star. Under high power (200x) this 12-arcsecond blue disc is impressive.

Chart key

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

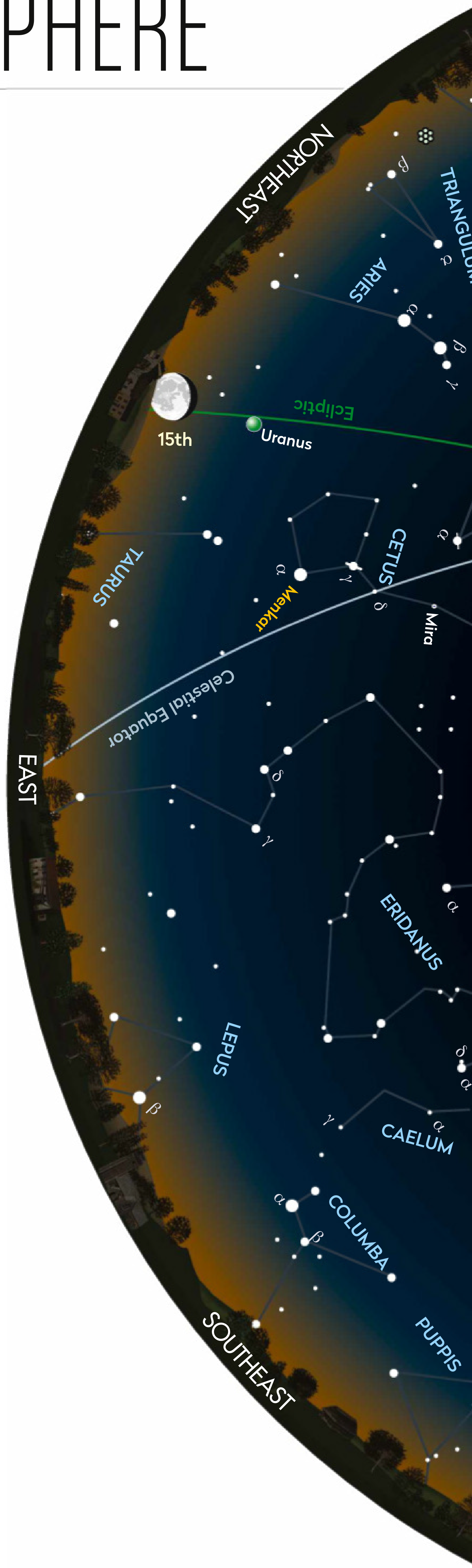
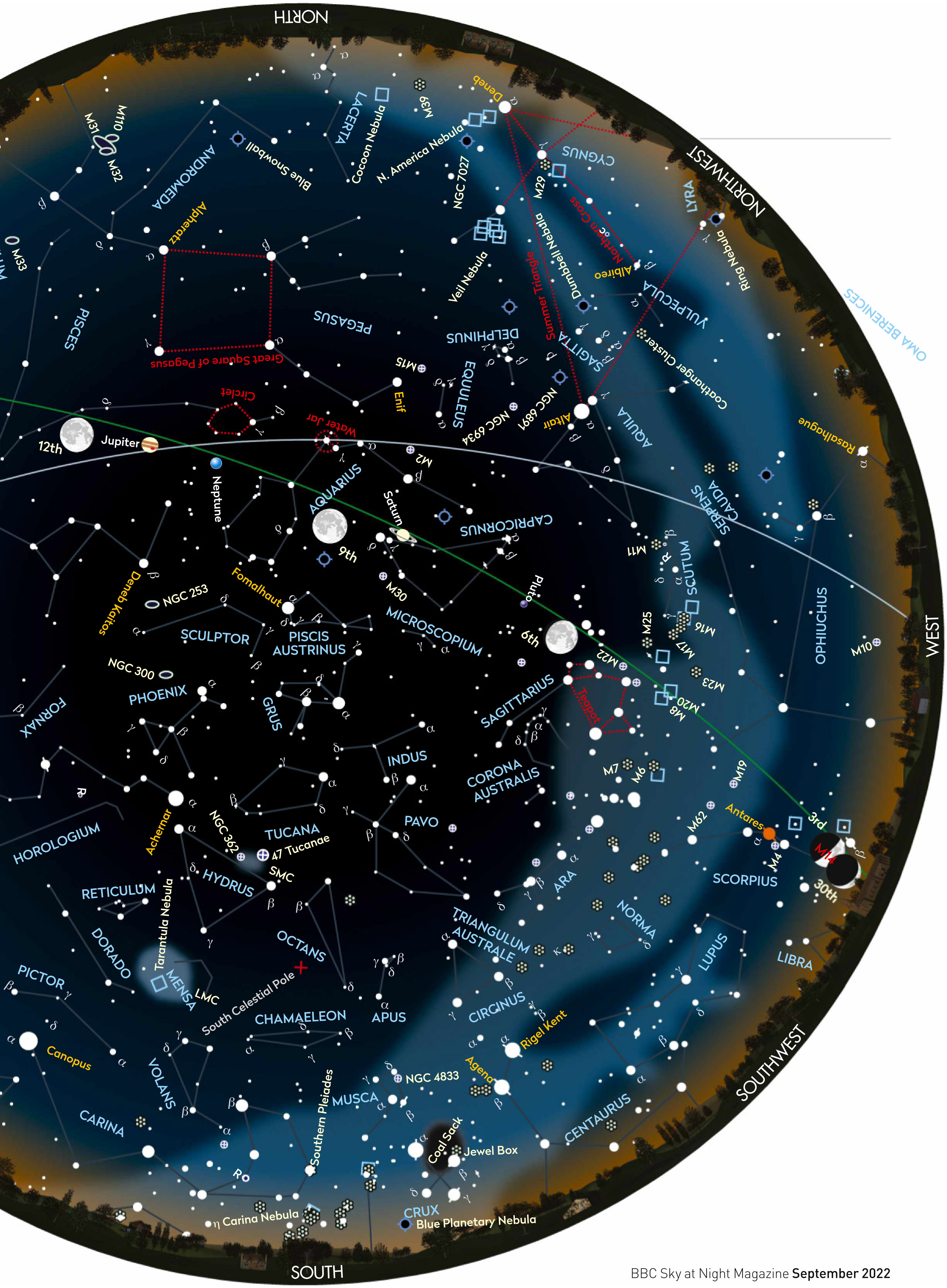


CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LACERTA
Cocoon Nebula
N. America Nebula
Deneb
M39
NGC 7027
CYGNUS
M29
Northern Cross
Dumbbell Nebula
Summer Triangle
Albireo
Veil Nebula
LYRA
Ring Nebula
VULPECULA
SAGITTA
DELPHINUS
Coathanger Cluster
Altair
AQUILA
NGC 6891
NGC 6934
EQUULEUS
M15
Enif
PEGASUS
Great Square of Pegasus
Alpheratz
ANDROMEDA
Blue Snowball
M31
M32
M110
M33
PISCES
Circlet
Water Jar
Jupiter
12th
Neptune
AQUARIUS
M2
Saturn
9th
CAPRICORNUS
M30
Fomalhaut
NGC 253
Deneb Kaitos
SCULPTOR
PISCIS AUSTRINUS
MICROSCOPIUM
Pluto
6th
M22
M25
M17
M16
M11
SCUTUM
SERPENS CAUDA
Rasalhague
OPHIUCHUS
M10
COMA BERENICES
SAGITTARIUS
Teapot
M20
M8
M23
NGC 300
PHOENIX
GRUS
FORNAX
INDUS
CORONA AUSTRALIS
M7
M6
M19
M62
Antares
M4
M14
3rd
30th
SCORPIUS
Achernar
HOROLOGIUM
NGC 362
47 Tucanae
TUCANA
PAVO
SMC
HYDRUS
RETICULUM
Tarantula Nebula
DORADO
OCTANS
TRIANGULUM AUSTRALE
NORMA
ARA
LUPUS
LIBRA
PICTOR
MENSA
LMC
South Celestial Pole
CHAMAELEON
APUS
CIRCINUS
Rigel Kent
Canopus
VOLANS
Southern Pleiades
MUSCA
NGC 4833
Agena
CENTAURUS
CARINA
Coal Sack
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Blue Planetary Nebula

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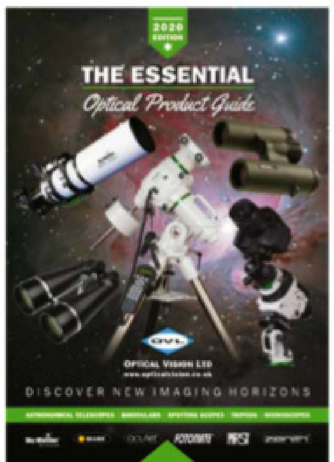

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